Fachhochschule Köln
Cologne University of Applied Sciences

UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ

FACULTADES DE CIENCIAS QUÍMICAS, INGENIERÍA Y MEDICINA

PROGRAMA MULTIDISCIPLINARIO DE POSGRADO EN CIENCIAS AMBIENTALES

AND

COLOGNE UNIVERSITY OF APPLIED SCIENCES

INSTITUTE FOR TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS

EVALUATION METHOD OF AN ENVIRONMENTAL MANAGEMENT SYSTEM OF HAZARDOUS SUBSTANCES IN THE INDUSTRY. *CASE OF A GERMAN-MEXICAN COMPANY*

THESIS TO OBTAIN THE DEGREE OF

MAESTRÍA EN CIENCIAS AMBIENTALES
DEGREE AWARDED BY UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ
AND
MASTER OF SCIENCE
"TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS
FOCUS AREA "ENVIRONMENTAL AND RESOURCES MANAGEMENT"
DEGREE AWARDED BY COLOGNE UNIVERSITY OF APPLIED SCIENCES

PRESENTS:

LESLIE AIDEÉ BOTELLO SALINAS

CO-DIRECTOR OF THESIS PMPCA:
DR. ALFREDO ÁVILA GALARZA
CO-DIRECTOR OF THESIS ITT:
PROF. DR. JOHANNES HAMHABER
ASSESSOR:
PROF. DR. CHRISTIAN SCHULZ

SAN LUIS POTOSÍ, MEXICO **AUGUST 31ST, 2010**

EVALUATION METHOD OF AN ENVIRONMENTAL MANAGEMENT SYSTEM OF HAZARDOUS SUBSTANCES IN THE INDUSTRY.
CASE OF A GERMAN-MEXICAN COMPANY

PROJECT CONDUCTED IN:

INSTITUTE FOR TECHNOLOGY AND RESOURCES MANAGEMENT IN THE TROPICS AND SUBTROPICS (ITT)

AND

PROGRAMA MULTIDISCIPLINARIO DE POSGRADO EN CIENCIAS AMBIENTALES (PMPCA)

CENTRO DE INGENIERÍA DE ESTUDIOS DE POSGRADO DE LA UNIVERSIDAD AUTÓNOMA DE SAN LUIS POTOSÍ

WITH THE SUPPORT OF:
DEUTSCHER AKADEMISCHER AUSTAUSCH DIENST (DAAD)
AND
CONSEJO NACIONAL DE CIENCIA Y TECNOLOGÍA (CONACYT)

THIS MASTER STUDY PROGRAM ON ENVIRONMENTAL SCIENCES IS SUPPORTED BY THE:
PROGRAMA NACIONAL DE POSGRADOS (PNP - CONACYT)

Erklärung / *Declaración*

Name / *Nombre*: Leslie Aideé Botello Salinas
Matri.-Nr. / *N° de matricula*: 1069551 (CUAS), 169632 (UASLP)

Ich versichere wahrheitsgemäß, dass ich die vorliegende Masterarbeit selbstständig verfasst und keine anderen als die von mir angegebenen Quellen und Hilfsmittel benutzt habe. Alle Stellen, die wörtlich oder sinngemäß aus veröffentlichten und nicht veröffentlichten Schriften entnommen sind, sind als solche kenntlich gemacht.
Aseguro que yo redacté la presente tesis de maestría independientemente y no usé referencias ni medios auxiliares a parte de los indicados. Todas las partes que están referidas a escritos o a textos publicados o no publicados son reconocidas como tales.

Die Arbeit ist in gleicher oder ähnlicher Form noch nicht als Prüfungsarbeit eingereicht worden.
Hasta la fecha, un trabajo como éste o similar no ha sido entregado como trabajo de tesis.

San Luis Potosí, den /*el* 31. August/31 de *Agosto*, 2010
Unterschrift / *Firma*: _____

Ich erkläre mich mit einer späteren Veröffentlichung meiner Masterarbeit sowohl auszugsweise, als auch Gesamtwerk in der Institutsreihe oder zu Darstellungszwecken im Rahmen der Öffentlichkeitsarbeit des Institutes einverstanden.
Estoy de acuerdo con una publicación posterior de mi tesis de maestría en forma completa o parcial por las instituciones con la intención de exponerlos en el contexto del trabajo investigación de las mismas.

Unterschrift / *Firma*: _____

DECLARATION

About the cases of study

Name: Leslie Aideé Botello Salinas
ID number: 1069551 (CUAS), 169632 (UASLP)

The information contained in this master thesis document, can be used only for academic purposes. The main objective of this research is to make an overall description of the Environmental Management Systems functioning and environmental performance in both industrial study cases, and not to display particularities on requirements compliance or possible legal breaches.

The descriptions of processes and chemical substances management were done from the information given during interviews with each plant's workers, product line supervisors and managers from the Environmental and Occupational Safety departments, as well as from multiple plant inspection visits, held on the specified dates, to:

ThyssenKrupp Bilstein Suspension GmbH, located in Hagen-Hohenlimburg, Germany; and *ThyssenKrupp Bilstein SASA, S.A. de C.V.*, located in San Luis Potosí, San Luis Potosí, Mexico.

I affirm that I made this master thesis document with only descriptive and educational purposes and non-profit or intentions of legal accusations.

San Luis Potosí, August 31st, 2010

Signature: _____

"Failure will never overtake me if my determination to succeed is strong enough."

– *Og Mandino*

To my Dad, I know that no matter what you'll always be with me,
Thank you for all your teaching, patience, love and just for being you;
To my Mom, for being the woman I'll always admire;
To my sisters, for your laughs, hugs, smiles and support;
And to my brother, for letting me be part of your growth.

ACKNOWLEDGEMENTS

First of all, I want to express my gratitude to God for the strength and support given along all this time and the opportunity of participating in this master study program in which I have experienced and learned from all good moments and difficulties. All this had influenced me, not only in the academic, but in personal and professional growth.

The present project could not have been finished without the constant and valuable collaboration and professional advice from my supervisors Dr. Alfredo Avila Galarza, Prof. Dr. Johannes Hamhaber and Prof. Dr. Christian Schulz, whose orientation and recommendations were of great significance not only in the developing and execution of this research, but at the same time for my own growth.

I want to acknowledge the great work that has been invested in along the execution of the ENREM program of all the involved people, from institutions (CONACYT and DAAD), directives, professors, students, secretaries and external collaborators. I have found that this program represents a very important opportunity for all students interested in different environmental aspects; I sincerely appreciate the great effort so far invested.

Additionally, I thank the support from the managers in both ThyssenKrupp industrial plants. I appreciate the confidence and orientation provided by Dr. Marcus Kattwinkel, Ing. José Luis Puga, Ing. Baldemar Escobar and Ing. Alma Noguchi as well as the working personnel from ThyssenKrupp Bilstein Sasa in San Luis Potosí, Mexico. In the same way, I thank the valuable contribution on this research from the managers in ThyssenKrupp Bilstein Suspension in Hagen-Hohenlimburg, Germany, particularly for the openness and support demonstrated during the fieldwork research from Ing. Simos Pashalis, Ing. Ulrich Rothe, Ing. Hellwig and Ing. Gabor.

I am grateful for the people that were by my side from the beginning of the Master's program. The large family Botello-Salinas, but specially my mother Betty, my sisters Betty and Danny and my brother Fernando, and my aunts Lupita, Blanca and Juanita who also supported me on the travels expenses. Then my friends, the ones who stayed there even if I had no much time, but cheered up, understood and encouraged me to move on: Rubi, Erika, Pablo, Marilu, Miriam and Julio; and the ones that started as classmates but turned into confidents, tutors, sisters and brothers: AleQ, Alesita, AnaJ, Anita, Anja, Ayax, Christine, David, Enma, Erika G, Flor, Irene, Isaak, John, Josue, Libby, Luis, Mara, Ricardo, Swen, Toa and Yazmín; we all have experienced and learned a lot from this part of our lives. I thank to all the people whose comments and constant support gave me strength and guided me in the bests and worsts.

ABSTRACT

Though the implementation of an Environmental Management System (EMS) in the industry can facilitate on hazardous substances (HS) management, the differences among industrial practices and applicable regulations from one region to another, make difficult to determine whether the a company meets its EMS's purposes or not.

Subsequently, even though companies demonstrate legal compliance on environmental requirements, it does not mean that they have an adequate environmentally or worker-healthy production system. Therefore, it is needed to evaluate the companies' EMS of HS from a precautionary standpoint and use a method that differentiates environmental behaviours among companies that have similar environmental objectives.

In the present study an evaluation methodology was developed consisting in five checklists with the aim of determine the environmental performance of a group of environmental elements (e.g., hazard waste management, wastewater treatment) and organizational elements (e.g., environmental policy, risk plans). In order to do this, different activities were involved as: interviews with EMS and process' managers and in-line workers, documents revision, e.g., safety data sheets (SDS) of HS, laboratory analysis and plant inspections, with the main purpose of gathering information required for the evaluation of the EMS of HS in a company.

The proposed evaluation method was applied to analyze the environmental performance of the EMS in two industrial plants, of the same German-Mexican company, that uses HS in its metallurgic processes. The elements of revision were evaluated in each plant and categorized according to the different environmental behaviours proposed: *Environmentally proactive, Environmentally active, Environmental legally acceptable* and *Environmentally inadequate*. To facilitate this, a descriptive matrix was used as a comparative base for the obtained results.

Then, the results from these elements of evaluation were integrated in their corresponding sectors, leading to the categorization of the environmental performance of the EMS of HS of each plant at the present time, allowing also the identification of strengths and improvement opportunities.

Finally, a comparative analysis between the results of both plants was carried out and permitted the identification of opportunity areas wherein the crossing of information between management departments of each plant would improve their HS management and their respective EMS.

RESUMEN

A pesar de que la implementación de los Sistemas de Manejo Ambiental (SMA) en la industria puede facilitar el manejo de sustancias peligrosas, las diferencias entre prácticas industriales y entre normas aplicables de una región a otra, dificultan determinar si una empresa cumple con los propósitos ambientales de su SMA.

Por lo tanto, a pesar de que las compañías demuestren cumplimiento legal de los requerimientos ambientales, esto no implica que mantengan un sistema de producción saludable para el trabajador o ambientalmente adecuado. Por lo tanto, se requiere evaluar el SMA de sustancias peligrosas de las compañías desde un punto de vista precautorio y utilizar un método que diferencie los comportamientos ambientales entre las compañías que cuenten con objetivos ambientales similares.

En el presente estudio se desarrolló una metodología de evaluación que consiste en la aplicación de cinco listas de chequeo, a fin de determinar el desempeño de una serie de elementos ambientales (ej. manejo de residuos peligrosos, tratamiento de aguas residuales, etc.) y de manejo organizacional (ej. política ambiental, planes de riesgo, etc.). Para esto se involucraron actividades como entrevistas con el personal administrativo, supervisores y trabajadores en los procesos de la planta; revisión de documentos (ej., hojas de seguridad de las sustancias, análisis de laboratorio) e inspecciones de planta, con el propósito de reunir la información para la evaluación del SMA de sustancias peligrosas en una empresa.

La metodología de evaluación propuesta se utilizó para el análisis del desempeño ambiental del SMA en dos plantas industriales, de una compañía Alemana-Mexicana, que utiliza sustancias peligrosas en sus procesos químico-metalúrgicos. Los elementos de revisión señalados fueron evaluados en cada planta y categorizados con respecto a los posibles comportamientos ambientales propuestos como: *Ambientalmente proactivo*, *Ambientalmente activo*, *Ambiental legalmente aceptable* y *Ambientalmente inadecuado*. Para facilitar esto se utilizó una matriz descriptiva que sirvió como base de comparación para las respuestas obtenidas.

Posteriormente, estos elementos de evaluación fueron integrados en sectores correspondientes, dando lugar a la categorización del desempeño ambiental actual del SMA de sustancias peligrosas para cada planta, permitiendo la identificación de fortalezas y oportunidades de mejora.

Finalmente, se realizó un análisis comparativo de los resultados obtenidos de ambas plantas, lo que permitió la identificación de áreas de oportunidad, donde el cruce de información entre los administradores correspondientes en cada planta resultaría en la mejora del manejo de sustancias peligrosas y su SMA respectivamente.

ZUSAMMENFASSUNG

Obwohl die Einführung des Umweltmanagement-Systems (UMS) in der Industrie für Gefahrstoffmanagement, die Unterschiede zwischen den industriellen Verfahren und zwischen den geltenden Vorschriften von einer Region zur anderen zu erleichtern scheint, ist schwierig festzustellen, ob die UMS tatsächlich der Erreichung ihrer Umweltzwecken dient.

Selbst wenn Unternehmen die Einhaltung rechtlicher Umweltanforderungen manifestieren, bedeutet es nicht, dass sie ein umweltfreundliches oder gesundes Arbeitnehmer-Produktionssystem haben. Daher ist es notwendig, dass das UMS der Gefahrstoffmanagement der Unternehmen aus vorsorglicher Sicht zu bewertet und eine Methode einzusetzen, die zwischen dem Umweltverhalten und ähnlicher umweltpolitische Ziele der Unternehmen, Differenzierungen macht.

In der vorliegenden Studie wurde eine neu entwickelte Bewertungsmethode angewendet, bestehend aus fünf Checklisten mit dem Ziel der Bestimmung der Umweltleistung von einer Gruppe von Umwelt-Elemente (zB Gefährdung der Abfallbewirtschaftung, Abwasserbehandlung) und organisatorischen Elemente (z. B. Umweltpolitik, Risiko-Pläne). Um dies zu erreichen, wurden verschiedene Aktivitäten durchgeführt, wie Interviews mit den Führungskräften, Vorgesetzte und Arbeitnehmern entsprechend der Prozesse der einzelnen Anlagen, Dokumente zur Überarbeitung (z. B. Sicherheit Datenblätter der Gefahrstoffe, Labor-Analyse) und Betriebsbegehungen, mit den Zweck der Sammlung von Informationen für die Bewertung der EMS von HS die in einem Unternehmen erforderlich.

Die vorgeschlagene Bewertungsmethode wurde angewendet, um die Umweltleistung der EMS in zwei Industriewerk zu analysieren, von einem deutsch-mexikanischen Unternehmen, das Gefahrstoffe nutzt in ihren metallurgischen Prozessen. Die Elemente der Revision waren in jeden Werke bewertet und kategorisiert wurden, hinsichtlich der folgenden verschiedenen Umweltverhalten: *Umweltfreundliche proaktive, Umweltfreundliche aktiv, Umweltrechtlich zulässig und Umwelt unzureichend*. Um dies zu vereinfachen wurde eine deskriptive Matrix als Basis verwendet um die erzielten Ergebnisse vergleichen zu können.

Danach wurden die Ergebnisse aus diesen Elementen der Bewertung in den entsprechenden Sektoren integriert, um der aktuelle Umweltverträglichkeit des UMS von Gefahrstoffe jedes untersuchten Werkes einzustufen, was die Identifikation von Stärken und Verbesserungsmöglichkeiten ermöglicht.

Schließlich wurde eine vergleichende Analyse durchgeführt, aus der Verbesserungsmöglichkeiten im Bereich des überschneidenden Informationsaustauschs der einzelnen Abteilungen der jeweiligen Industriewerke erkannt wurden. Dies könnte den kontinuierlichen Verbesserungsprozess der jeweiligen UMS begünstigen.

SYMBOLS, ABBREVIATIONS AND ACRONYMS

ChemG	Law on the protection from hazardous substances *(Chemikaliengesetz* or *Gesetz zum Schutz vor gefährlichen Stoffen)*
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EMS.1	Document EMS.1. Environmental Management System Revision
GefStoffV	Regulation for the protection against hazardous substances *(Verordnung zum Schutz vor Gefahrstoffen)*
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
HS	Hazardous substances
HSA.1	Document HSA.1. Hazardous Substances Analysis – Process description
HSA.2	Document HSA.2. Hazardous Substances Analysis – Safety Data Sheet Analysis
ISO 14001	International Standard ISO 14001 that sets out requirements for an EMS
ISO 9001	International Standard ISO 9001 that sets out requirements for Quality Management Systems
ISO	International Standard Organization
LGEEPA	General Law on Ecological Balance and Environmental Protection *(Ley General de Equilibrio Ecologico y Proteccion al Ambiente)*
LGPGIR	General Law for Waste Prevention and Comprehensive Management *(Ley General para la Prevención y Gestión Integral de los Residuos)*
OHSAS	Occupational Health and Safety Assessment Series
PM.1	Document PM.1. Process Managers Interview
ROA.1	Document ROA.1. Results and Opportunity Areas
SDS or MSDS	Material's Safety Data Sheets
SEMARNAT	Ministry of Environment and Natural Resources *(Secretaría de Medio Ambiente y Recursos Naturales)*
STPS	Secretariat of Labour and Social Welfare *(Secretaría del Trabajo y Previsión Social)*
TK-Hagen	ThyssenKrupp Bilstein Suspension GmbH, in Hagen-Hohenlimburg, Germany
TK-SLP	ThyssenKrupp Bilstein SASA, S.A. de C.V., in San Luis Potosí, San Luis Potosí, Mexico
UN	United Nations
VI.1	Document VI.1. Visual Inspection of Hazardous Substances Management Stages
WI.1	Document WI.1. Worker's Interview

TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

INTRODUCTION

Nowadays, there is a large variety of industrial processes that involve the use of hazardous substances (HS), identified by their properties as: corrosive, explosive, toxic, flammable, dangerous for the environment, among others.

The HS management in the industry is an important issue to attend for environmental and humans' health protection. In this matter, it is acknowledged the current international effort on improving such management by promoting conferences, international joint programs and treaties on the subject.

However, the outcomes of these efforts have not been adequately integrated into many countries regulations, which in some cases can even be considered as insufficient to prevent humans' health and environmental damage.

For this reason, it is possible that international companies present different environmental behaviours on different plant locations, like the cases of the German and Mexican plant of the same international industrial company presented in this study.

However, despite the sufficiency and differences of legal environmental requirements on the different locations, the responsibility of the damage that industrial activities could cause involving HS will always lay on the very own management of each plant. It is decision of the company's management whether to look only for satisfying those environmental requirements and therefore avoid legal sanctions, or to seek for an improved HS management in order to minimize environmental risk and impact, have a more efficient use of resources and less quantities and/or lower hazard on their generated waste.

Moreover, it is regularly looked as a sign of environmental care the adoption of international guidelines of EMS, (i.e., ISO 14001 and EMAS) and the certification on the compliance of such standards. However, such systems give mostly an organizational structure to facilitate the revision on compliance of legal requirements, not necessarily implying actual environmental damage prevention.

Furthermore, the inclusion of the continuous improvement concept could not necessarily be applied on the upgrading of applicable legal requirements, but to other issues, e.g., improvement on legal compliance rate or reduction of the number of incidents in the area.

Taking this into consideration, the contribution from this study represents an effort to differentiate among environmental performance of industrial activities in several selected aspects from the HS management. In this case, two plants of an industrial German-Mexican company count with an established and certified EMS based on the compliance of the standard ISO 14001, but present different levels of performance in the evaluated aspects.

The evaluation method for EMS proposes the systematic revision of different important issues to consider on HS management. Additionally, establishes a categorization system of the obtained results based on four possible types of environmental behaviours taking into account concepts of continuous improvement, sustainability and precautionary principle, with the final aim to differentiate between different types of environmental care as: proactive, active, legally accepted and inadequate.

CHAPTER I.

RESEARCH BASES AND FOUNDATIONS

1.1 THE PROBLEM OF INADEQUATE SUBSTANCES MANAGEMENT.

The exposure to chemical substances involved in many industrial processes endangers worker's health and the integrity of the environment in the surroundings of the place in which such activities are being done.

Inadequate handling, storage or transportation could probably result in accidents, which cost environmental damage and, in many cases, even human lives. Therefore, it is important that industries count on adequate management systems that regulate such activities.

Nowadays, many countries with industrial activity impose by law some general requirements, as:

- Documentation of all substances involved in their processes, including toxicity, health danger, handling protection equipment, storage conditions, etc. This information is resumed in the Material Safety Data Sheets of each substance and must be provided by the supplier company.
- Adequate workplace conditions and safety equipment to protect workers health, which are commonly found and specified on the countries' legislation.
- Report of environmental emissions and wastewater discharges, which must not overpass the limits established by the government authorities in each respective location.

In order to fulfil these requirements some companies adopt an environmental policy and goals, and so they follow international standards, as the ones from the International Standards Organization (ISO), the Occupational Health and Safety Assessment Series (OHSAS) and the Eco-Management and Audit Scheme (EMAS).

Although these guidelines are descriptive and clear, they don't integrate the special handling for hazardous substances (HS).

Furthermore, neither Mexico nor Germany has required by law to have a documented and organized Environmental Management System, this gives all industrial companies the liberty to formally implement it or not, and at the same time an uncontrolled system is more difficult to verify and subsequently an activity susceptible for incompliance.

Additionally all EMS must be adapted to each company's activities and to the regional regulations, by these reasons it is difficult to count with a general methodology that reveal the environmental behaviour of the company on the use of HS.

Finally, industrial companies must aware that EMS certification is not an overall solution to neither to environmental problems, environmental impacts nor industrial safety.

1.2 RESEARCH QUESTIONS.

When talking about HS danger and realizing about the problems that inadequate management can brought, the implementation of an EMS into the industry seems to represent a good answer, but the adaptation and the different regulations on the subject make difficult to determine if these EMS are actually achieving the environmental purposes.

Moreover, companies can have a regulatory acceptable behaviour and so, demonstrated by internal audits, but it does not mean that these companies have at the same time an acceptable environmentally or worker-healthy production.

Then, regarding this information some important questions can be set on order to lead this research:

- Is an adequate HS management integrated in the company's EMS?
- Are industrial companies' EMSs following the adequate procedures that actually assure a environmentally and worker's safe HS management?
- Is it enough for a company's environmental performance only to consider environmental regulations in their processes and activities?
- How can the EMS's of HS be evaluated in order to determine its actual environmental performance?
- Can an evaluation method differentiate between environmental behaviours and identify opportunity areas in the EMS of HS?

1.3 PROJECT HYPOTHESIS.

"The proposed methodology would let the characterization and evaluation of the Environmental Management System of hazardous substances in a company, consequently describe the company's environmental behaviour and identify the improvement opportunities on the subject."

1.4 OBJECTIVES OF THIS RESEARCH.

The general objective in this research is to analyze the EMS of hazardous substances in an industrial company, then develop a methodology that leads the characterization and evaluation of the system.

1.4.1 Specific objectives.

In order to assist the achievement of the proposed general objective, the following specific objectives have been set:

1. Collect and analyze documented information about EMS structure and HS management in the legal, national and international guidelines framework.
2. Establishment of a cooperation agreement with an industrial German-Mexican company that involve the use of HS in its process, in order to have access to the information needed to facilitate this research.
3. Determine the elements of evaluation and set the different categories of environmental behaviour basing on international environmental principles, in order to propose a methodology for evaluating the EMS performance on the use of HS.
4. Apply the developed methodology to characterize the EMS of HS and evaluate its environmental performance in a German and a Mexican production plant of the same industrial company.
5. Identify opportunity areas in each company's EMS in order to guide possible changes that lead to environmental performance improvements.
6. Carry out a comparative analysis between systems, identifying similarities and differences as well as strengths and opportunity areas regarding HS management that may be improved by crossing company's knowledge and expertise in the area.

1.5 GOALS TO ACHIEVE.

1. Explanation of a conceptual framework that supports the proposed methodology.
2. Create a collaboration agreement with an industrial German-Mexican company that involve the use of HS in its processes.
3. Understanding of the industrial processes that involve the use of HS, as well as their identification among inputs and outputs.
4. Characterization of the EMS of the company that describing its main elements: policy and objectives.
5. Creation of an evaluation tool including: information gathering formats and categories setting, that lead to describe the EMS of HS performance.
6. Identification of strengths and opportunity areas in the EMS of HS.

7. Comparison of the systems performance both German and Mexican plants of the company's EMS of HS.

1.6 EXPECTED RESULTS.

The expected results of this study are:

1. Obtain a systematized and useful methodology that guide the evaluator to categorize the environmental performance of an EMS of HS of an industrial company.
2. Identify weakness and strengths of the company's EMS on HS management performance on the different mentioned aspects that this methodology evaluates.
3. Guide the company to prioritize the different possible changes on the opportunity areas to detect.
4. Serve as part of a comparison strategy, between plants of a company that should reach the same high level of environmental performance.

1.7 SCIENTIFIC WORK. PROJECT DEVELOPMENT AND RESEARCH STAGES.

1.7.1 Project construction and definition.

This is the first stage of the project, in which its main purpose, first set of objectives, hypothesis and goals were set. Nevertheless, these elements of the study were revised and redefined along the whole progress of the study.

1.7.2 Bibliographic research. Conceptual framework construction.

Research information and data had to be gathered from different reliable sources; e.g., published revised literature, different examples of documented EMS and international guidelines for EMS requirements and implementation procedures. The gathered information covered the following subjects:

1. Environmental principles[1] and influence on industrial management
2. Environmental Management Systems
3. EMS evaluation methods
4. Hazardous substances management
5. German legal framework on HS management
6. Mexican legal framework on HS management

[1] *Those emerged by environmental pollution concern, mainly Precautionary principle, Polluter pays principle (PPP) and Cooperation principle.*

Other important reliable data was obtained from first hand, as personal interviews with experts on subjects as the legal framework Germany and Mexico, EMS implementation and certification processes, also it must be considered the interviews with the company's managers and responsible of the EMS implementation and revising.

As well as the last stage this step was also developed along the whole time of study research, therefore the bibliographic reference backup was extended and updated.

1.7.3 Methodology proposal development stage.

This stage makes reference to the time when the descriptive evaluation tool for an EMS of HS in the industry was developed, particularly from the beginning of the study research development until its application for the evaluation of the EMSs of HS from each of the two study cases.

The explanation and bases for the application of the evaluation tool is done on Chapter V; however, the main actions involved in the development stage for this methodology involved a reflective process to integrate the gathered information, in order to form:

1. Methodology bases and objectives.
2. Set the elements of evaluation and levels of the industrial companies' performance on environmental behaviour based on: International environmental principles, international EMS standards and both countries legal requirements.
3. Checklist drafts and structured interviews with grading of possible answers.

1.8 FIELDWORK RESEARCH. ON-SITE RESEARCH METHODS, LIMITATIONS AND RELEVANT ELEMENTS.

1.8.1 Industrial collaboration agreement with a German-Mexican Industrial Company.

As it has been described, in order to reach the objectives of this project, it was necessary to have the collaboration of an industrial company that involved dangerous chemical substances in their processes or parts of them.

Furthermore, the cooperation of a German-Mexican industrial company was of special interest in this research since one of the sought purposes of the project was not only the development of an evaluation tool and its application regardless the home country of the company, but also reflecting on its adaptability to different practices, environmental management styles and the fulfilment of the requirements of a conventional Environmental Management System.

Therefore, as an additional purpose of the project, a possible comparison between those systems would be done, this may contribute to the continuous improvement goals of each company.

Finally, is important to mention that this master thesis project has a predominantly scientific research objective and therefore it represents a contribution for the academic efforts on Environmental sciences. Nevertheless, it is important to consider and mention the benefits that the industry and more properly the involved company in this study, may acquire as:

1. Knowledge of the company's environmental behaviour on HS management.
2. A methodology for evaluation of the EMS of HS, revised and adjusted to its process, which will be reported to the company.
3. The periodically application of this methodology may contribute to the continuous improvement goals of the company.

The results and procedures would be resumed in a final technical report that would be delivered to the company. Also a copy of the master thesis document result of this study would be available for the collaborators.

1.8.1.1 Limitations and restrictions on confidentiality agreement.

As mentioned before, the fieldwork research during the carry out of this master thesis project involves industrial cooperation; therefore, it is important to realize about company's restrictions on accessing information related with confidential processes.

Therefore, some activities and documentation won't be reported even though are available for the researcher in order achieve the purposes of this project. Some of the followed restrictions and limitations to be considered were:

1. Report of chemical content of some active substances used on the plants processes.
2. Report (or in some cases taking) of photos during the plant inspection.
3. Report of confidential documents, e.g., plants' Environmental Management System manuals, analysis of toxic substances.
4. Plant inspections and interviews were subjected to the supervisors and department managers' time availability.

1.8.2 Fieldwork methods I. Description of the company *Status-quo* on hazardous substances management.

The first stage of the fieldwork research has as its main purpose the gathering of information from both plants of the industrial company about the processes that involve the use of hazardous substances and their production of hazardous waste.

This project is limited to the study of only three industrial processes: Pre-treatment, Coating and Wastewater Treatment. The reason for this is that the two industrial plants apply the same processes, and they include majority of the company's managed HS.

In this stage it is also important to describe the company's environmental policy and the adopted standards in order to validate their respective EMS. To facilitate this fieldwork a list of main objectives were proposed:

1. *Data collection about the environmental policy of the company.*
   a. Actual Environmental Management System of the company.
   b. International EMS standard followed by the German-Mexican company.
   c. Laws and mandatory requirements that the company has to fulfil.

2. *Knowledge and description of the processes involving dangerous chemical substances.*
   a. Process inspection in the company's plant.
   b. Make of schematized process diagram indicating chemical substances incomes and outcomes.

3. *Identification of dangerous and non-dangerous chemical substances in the process.*
   a. Collection Material Safety Data Sheets (MSDS or SDS).
   b. Collection toxic waste analysis reports.
   c. Knowledge of final disposal of toxic waste.

4. *Information gathering from structured interviews about company's EMS and plant practices.*
   a. In the Process – Technicians and workers. To know where and how are Hazardous Substances used; emergency preparedness.
   b. EMS related information – Environmental Dept. Manager. To complete and understand company's environmental policy and EMS structure.
   c. Hazardous Substances Management – Process(es) manager(s). To know about the research and introduction of materials and technologies on the processes to reduce environmental impact; waste transportation and disposal concern.

5. *Information verification.*
   a. Revision of process description and missing data gathering.
   b. First hand information revision through Company's fieldwork visits report.

1.8.3 Fieldwork methods II. Evaluation of the EMS focusing on hazardous substances management in the company.

The second stage of the fieldwork research has a more practical purpose, meaning the application of the developed and adapted methodology for the characterization and evaluation of the companies' EMS of HS, this is done by analyzing the previous gathered information.

Since this part of the scientific methodology involves directly the descriptive steps on the evaluation tool, they are further widely described on Chapter V. However, this section gives the general concepts and objectives of the following evaluation steps:

1. *Information gathering and begin of evaluation stage.*
   Use of the corresponding checklists to collect the information about different aspects on HS management. This stage involves activities such as: interviews with the management personnel, supervisors and line workers of the processes of each plant; documents revision (e.g., Safety Data Sheets of the HS, laboratory analysis) and plant inspections; in order to gather required information for the analysis.

2. *Analysis of the obtained results.*
   Description of the environmental performance of the plant's EMS of HS, by comparing the obtained answers with the information in the developed matrix for this evaluation tool. This matrix sets, for each element of revision, four types of probable environmental behaviours: *Environmentally proactive, Environmentally active, Environmental legally accepted and Environmentally inadequate*.

3. *Final report. Results and opportunity areas.*
   Categorization of the obtained results, in order to identify strengths and opportunity areas in both cases of study using the obtained environmental behaviour of each element of evaluation.

1.9 REPORTING RESEARCH RESULTS AND CONCLUSIONS.

As final products of this academic study, two documents have to be elaborated: a Master Thesis document and a final technical report. The first one is the academic compendium of the whole research which had to be judged by the study supervisors committee and includes the following elements:

- Project proposal, bases and foundations.
- Scientific work development.
- Conceptual background and consulted references.
- Evaluation tool development and description.

- Study case description, application experiences and findings.
- Research results and conclusions.
- Appendixes (gathering information formats and relevant laws)

The second document refers to the technical report, which has to be delivered to each plant involved in this study. This document would include the following elements:

- Process description diagrams.
- Hazardous Substances identification documents.
- Description of the Evaluation Methodology.
- Information gathering formats (Documents HSA.1, HSA.2, VI.1, EMS.1, PM.1 and WI.1,).
- Analysis tables.
- Conclusion on company's EMS performance on the studied Hazardous Substances management.

CHAPTER II.
CHEMICAL INDUSTRY AND HAZARDOUS SUBSTANCES

Due to the rapid increase in the variety and availability of chemicals in the past 40 years, today there can be identified more than 11 million chemicals (natural and man-made) of which only a small fraction is available for marketing. In the past, most of the production was held in Europe and North America, but now it has spread to newly industrializing countries of East Asia, increasing the proportion they enter into the market (Márquez R., n.d.).

The chemical industry has synthesized and used a variety of hazardous substances (HS), which can be defined as those that by themselves or as chemical mixture present properties classified as: flammable, explosive, toxic carcinogenic, corrosive, radioactive or chemical-reactive properties (Carson & Mumford, 2002).

These substances have a directly or indirectly application in the processes, among the most common uses include solvents, pesticides, explosives, fuels and raw materials for other products. Figure 2.1, shows a single general scheme that describes the different stages that most of the chemical substances go through industrial processes (Cortinas de Nava, 2000a).

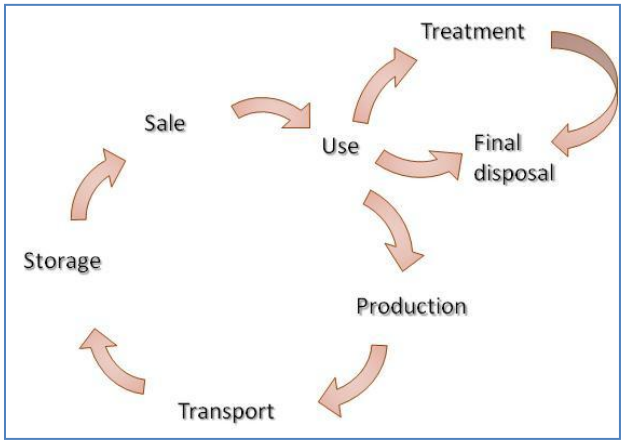


Figure 2.1 *Chemical substances path through industrial processes (Modified from Cortinas de Nava, 2000b).*

Nevertheless, in the analysis of this path on Figure 2.1 is important to remark that in many cases substances cannot be reuse and so they go into chemical or physical treatments for their final disposal, or directly to their final disposal without any treatment at all. This fact cuts the apparent "life cycle" of the substances, letting the final products of industrial activity in a confined, dangerous and not-easy to handle deposit of dangerous waste.

There is another missing point in this path that can be noticed, it excludes any environmental connection between the different stages and the surroundings, for example, the atmospheric emissions during the use stage, the release of "minor" quantities of pollutants from treated

wastewater after the company's own treatment, and the possible leakages or soil impact from final destination of substances deposits.

The Environmental Protection Agency (EPA) of the United States has identified 35 thousand chemicals which are potentially harmful to human health. The widespread use of these hazardous substances in production processes has forced society to function in the limits of risk, involving the danger posed to health and life itself (Anglés-Hernández, 2006).

2.1 HEALTH EFFECTS FROM EXPOSURE TO HAZARDOUS SUBSTANCES.

By involving the handling of hazardous chemicals in any process, it must be considered that exposure to them, depending on toxicity, frequency and extension of exposure can have adverse effects on health of workers.

Table 2.1 shows some hazardous substances that have been used in industry in recent years, and a brief description of the health effects of exposure that can be caused by an inadequate management of such chemicals.

Table 2.1 *Health effects from exposure to hazardous substances (Anglés Hernandez, M., 2006).*

HAZARDOUS SUBSTANCE	COMMON USES	HEALTH EFFECTS
Arsenic	In agriculture as pesticides, but also used in metallurgic, paint and paper and pharmaceutics	Cancer risks (different kinds), chronic intoxication, neurological problems, vascular disorders and anemia
Asbestos	Production of cement, plastics, textiles, water tanks and roofing sheets	Asbestosis (lung fibrosis), *Mesothelioma cancer* (mainly pleural).
Benzene	Fungicides production, also found in fireworks, ammunition and synthetic rubber	Multiple clinical involvements, including the liver, kidneys, immune system, thyroid and central nervous system and cancer
Cadmium	Antioxidant, plastic production, paints and enamel colorant	Chronic intoxication, pulmonary edema, renal failure, kidney stones and lung emphysema
Byphenil	Insulating materials in PCBs capacitors and transformers, plasticizers, adhesives, plastics and paints	Eye irritation, gastrointestinal disorders and menstrual decline in female fertility
Chlorine	Manufacture of bleaching agents, solvents, pesticides and plastics	Acute intoxication, pulmonary edema and pneumonia
Hydrocarbons Derivates	Gasoline, solvents, textiles, paints, dry cleaning fluids, inks, latex, pharmaceuticals explosives, fungicides and other chemicals	Eye irritation, asthma, pulmonary edema, burns, anemia, chronic poisoning, menstrual disorders, coma and death
Mercury	Metals melting and as fungicide	Poisoning, neurological disorders and death by poisoning
Pesticides	Pests control	Central nervous system damage, cancer, anemia, sterility, mutagenic
Beryllium	Production of nuclear reactors, aerospace industry, electronics alloys	Alterations in the respiratory tract, lung cancer and bone

2.2 RISK AND CHEMICAL DANGER IN THE USE OF HAZARDOUS SUBSTANCES.

As mentioned previously, exposure to hazardous substances involved in industrial processes can jeopardize both worker's health and the environment's integrity on the surrounding places where the activity takes place.

Therefore, assessment studies are needed in order to identify the chemical hazard potential of the use of a substance, and its overall management, in order to realize about the a possible adverse effect on health when used under certain conditions, or the risk conditions in which workers and surrounding communities are exposed, or environmental impacts that those substances can generate. One of the most common known assessment studies is the Risk Assessment Study, that pursuits to find the potential health risk that the use of a substance represents to life. Generally, a chemical risk assessment basically consists of the following elements (Anglés Hernandez, M., 2006):

1. Substance's hazard identification.
2. Evaluation of the substance's toxicological information.
3. Estimation of routes of exposure, frequency, magnitude and duration.
4. Risk characterization, integrating all collected information.

Then as a general first step, it is important to know the substance, which can be done by analyzing the reported information about it. The most important elements are resumed on Table 2.2. As can be seen, many of these elements can be found in the Safety Data Sheet (SDS) of the substances, which can be provided by the substance supplier or also be found in materials hazards handbooks.

Nevertheless, the hazard of a substance is not only related to what harm can the substance do to the living beings, it is also directly related with the impact it represents to the environment, e.g. due to its presence on wastewater discharges, potential soil deterioration resulted from spills or underground storage leakages, or air pollution from emissions or small particles release into the atmosphere, in which case some relevant elements to consider are shown on Table 2.2.

For that reason, industrial companies must take special care in order to plan their activities, and attend carefully to the information provided with the substances that are being used as input materials, and so, follow the indications on proper storage, labelling, handling, and final disposal.

Table 2.2 *Comprehensive information possibly required for hazardous substances identification (Carson & Mumford, 2002).*

NAME OF CHEMICAL (IUPAC OR OTHER NAMES)	
USES	
GENERAL DESCRIPTION OF HAZARDS	
GENERAL DESCRIPTION OF PRECAUTIONS	
Fire-fighting methods	
Regulations	
Sources of advice on precautions	
CHARACTERISTICS: EVALUATE AS APPROPRIATE UNDER ALL PROCESS CONDITIONS	
Formula (chemical structure)	
Purity (identity of any contaminants), physical state, appearance, other relevant information	
Concentrations, odor, detectable concentration, taste	
PHYSICAL CHARACTERISTICS	
Molecular weight	Particle size; size distribution
Vapor density	Foaming/emulsification characteristics
Specific gravity	Critical temperature/pressure
Melting point	Expansion coefficient
Boiling point	Surface tension
Solubility/miscibility with water	Joule-Thompson effect
Viscosity	Caking properties
CORROSIVITY	
Contamination factors (incompatibility), oxidizing or reducing agent, dangerous reactions	
FLAMMABILITY INFORMATION	
Flash point	Vapor pressure
Fire point	Dielectric constant
Flammable limits (LEL, UEL)	Electrical resistivity
Ignition temperature	Electrical group
Spontaneous heating	Explosion properties of dust in a fire
Toxic thermal degradation products	
REACTIVITY (STABILITY) INFORMATION	
Acceleration rate calorimetry	Thermal decomposition test
Differential thermal analysis (DTA)	Influence test
Impact test	Self-acceleration temperature
Thermal stability	Card gap test (under confinement)
Lead block test	JANAF
Explosion propagation with detonation	Critical diameter
Drop weight test	Pyrophoricity
BIOLOGICAL PROPERTIES	
EXPOSURE EFFECTS	
Inhalation (general)	Skin and respiratory sensitization
Respiratory irritation	Mutagenicity
Ingestion	Teratogenicity
Skideye irritation	Carcinogenicity
RADIATION INFORMATION	
Radiation survey	
Alpha/ beta/gamma/neutron exposure and contamination	

Table 2.3 *Basic data for environmental risk assessment (Carson & Mumford, 2002).*

POTENTIAL RISK TO THE ENVIRONMENT
Aquatic toxicity (e.g. to fish, algae, daphnia)
Terrestrial toxicity (to plants, earthworms, bees, birds)
Biotic degradation
Abiotic degradation
Photodegradation
Biochemical oxygen demand
Chemical oxygen demand
Hydrolysis as a function of pH
Bioaccumulation
Oil/water partition coefficient

Then, according to the quantities in which the substance is being used, transport or stored, it might change the intensity of the impact, becoming higher when large quantities are used, or lower when they are small, or for some environmental considerations when they are dissolved and reach a level in which the ecosystem can safely manage it. As a matter of fact, legal regulations over the world consider also quantities of use to classify the risk on such practices, managing a specific quantity for each identified hazardous substances listed by their laws.

Such are cases of: the European Community companies, which must notify authorities when they reach specific levels in their storage or use of specific substances; the United Kingdom, where since 1992 a special “hazardous substances consent” is required when is intended to hold any of 71 listed substances above a ‘controlled quantity’; or in Mexico, where industrial practices are classified as “high risk activities” when involve the use of any listed substances, classified as toxic, inflammable and explosive, in levels that overpass an established “quantity of report” (Carson & Mumford, 2002).

It is also important to mention that the prevention and precautionary principles are the basis for the methodologies for health and environment risks assessment. The prevention principle is based on anticipated measures founded on verified knowledge in order to minimize environmental degradation, or also health deterioration, while the precautionary principle is used to take actions with acceptable social and economic cost, based on probability of risk in response to scientific uncertainty (Anglés-Hernández, 2006).

2.2.1 Hazard symbols and visual Identification.

Chemical substances containers visual identification is worldwide regulated, since that is the way in which the person who is in direct contact with the substance, can be aware about the risk he is being exposed and would decide on the safety measures he must take. Notice that the worker should be trained before he is in contact with these substances, in order to properly interpret the hazard symbols and indications on the substance container's label.

There are international recognizable hazard symbols or pictograms, as well as international standards guidelines that describe how these symbols should be used. Common examples of these hazard symbols are shown on Figure 2.2. Then it is relevant to remark that even though they are very similar, there are different in their use and applicability (ACA, 2010):

- The standard 704 or "***Fire diamond***" from the United States National Fire Protection Association (NFPA 704), used by emergency response personnel (fire fighters, hazardous materials workers, police, etc.) under emergency conditions;

- The ***Colour Bar*** from the Hazardous Materials Identification System (HMIS Colour Bar) by the National Paint & Coatings Association (NPCA) as a compliance aid for the United States Occupational Safety and Health Administration (OSHA) Hazard Communication Standard, used by employers and workers on a daily basis and provides information on acute and chronic health hazards, flammability, physical hazard, and personal protective equipment.

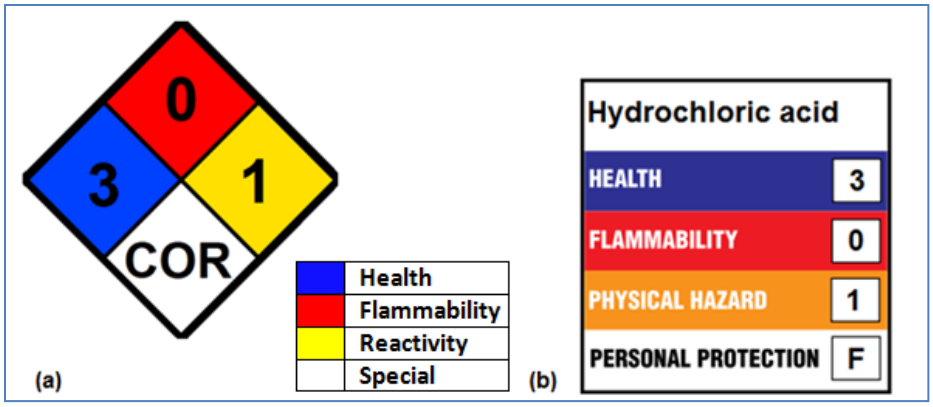


Figure 2.2 *Examples of common hazard identification symbols for Hydrochloric acid: (a)NFPA 704 standard; (b) HMIS III.*

Also, they can be easily confused with the regulated symbols for hazardous chemical substances transportation, including labelling and packing indications, which are stipulated by national agreement in each country; however they are regularly based on international agreements, and are explained in the following sections.

2.3 INTERNATIONAL EFFORTS FOR SAFE HANDLING OF HAZARDOUS SUBSTANCES.

An adequate, conscious and careful management of hazardous chemicals involved in production processes is a matter of international concern, due to the industrial expansion in both industrial and developing countries, finding that inadequate management can lead to severe accidents, as shown on Table 2.4.

Table 2.4 *Examples of Worldwide Chemical Accidents (World Health Organization, 2007).*

YEAR	LOCATION	ACCIDENT	CHEMICAL SUBSTANCE RESPONSIBLE	DEAD	INJURED	EVACUATED
1998	Yaundé, *Cameroon*	Transport accident	Petroleum products	220	130	----
2000	Kinshasa, *Democratic Republic of the Congo*	Ammo storage (explosion)	Explosives	109	216	----
2000	Enschede, *Netherlands*	Plant (explosion)	Explosives	20	950	----
2001	Toulouse, *France*	Plant (explosion)	Ammonium nitrate	30	> 2500	----
2002	Lagos, *Nigeria*	Ammo storage (explosion)	Explosives	1000	----	----
2003	Gaoqiao, *China*	Gas well (escape)	Hydrogen sulfide	240	9000	64 000
2005	Huaian, *China*	Truck (escape)	Chlorine	27	300	10 000
2005	Graniteville, *United States of America*	Train cistern (escape)	Chlorine	9	250	5400
2006	Abidján, *Côte d'Ivoire*	Toxic waste	Hydrogen sulfide, mercaptanes, Sodium hydroxide	10	> 100 000 *(not verified)*	----

For this reason, conferences and meetings at international level including a large number of countries interested in human health and environmental care have concluded on agreements and proposals that guide the use of these substances.

Table 2.5 shows some examples of worldwide conferences and international organizations efforts that, recognizing the potential danger on the use of hazardous substances, have been working on the development of classification systems, work codes, information trading systems, risk assessment, among other important contributions in order to improve the hazardous substances management, therefore protect the human health and environmental integrity.

Table 2.5 *Some of the most important international efforts related to Hazardous Substances Management.*[2]

ORGANIZATION RESPONSIBLE	CONTRIBUTION ON HAZARDOUS SUBSTANCES MANAGEMENT IMPROVEMENT
UN Conference on the Human Environment *(Stockholm, 1972)*	• States relevance on controlling discharges of toxic substances into the environment in order to ensure that serious or irreversible damage is not inflicted upon ecosystems. • International governmental guidelines to avoid toxic substances discharges • Programs about propagation of contaminant agents (sources, pathways, exposition levels and relative risks) • Creation of the United Nations Environmental Program (UNEP)
UN Environment Programme (UNEP)	• Development of the International Register of Potentially Toxic Chemicals, IRPTC (1976) • Rotterdam Convention on the Prior Informed Consent (PIC, into force 2004) • Awareness and Preparedness for Emergencies at Local Level Handbook (APELL) • Code of Ethics on the International Trade in Chemicals • Generation of the "Harmful substances and hazardous wastes" UNEP sub-program
UN Conference on Environment and Development *(Rio de Janeiro,1992)*	Publication of **Agenda 21**, six programmed areas relating chemicals management covering: - international promotion of risks assessment; - harmonization of classification and labelling systems; - Strengthening of national capabilities and capacities for management of chemicals; - risk reduction programmes; - information exchange on toxicity and risks; - Prevention of international illegal traffic and activities to protect public health
UN World Summit on Sustainable Development or Earth Summit 2002 *(Johannesburg, 2002)*	• Renew commitment on Agenda 21, by including a sound management of chemicals throughout their life cycle and of hazardous wastes, in its plan of implementation
International Labour Organization (ILO)	• Agreements and recommendations for prohibition and limits on use of dangerous substances (lead, benzene, asbestos) • Prevention on mayor industrial accidents and work risk on agriculture.
World Health Organization (WHO)	• In charge of dangerous substances and waste analysis • Creation of the Centre for Sanitary Engineering and Environmental Sciences (CEPIS) in Latin America, part of the Health and Environment Division of the Panamerican Health Organization, delegate of the WHO.
Food and Agriculture Organization (FAO)	• International Code of Conduct on the Distribution and Use of Pesticides (1985)

[2] *Developed with information from: Anglés-Hernández, 2006; UNEP, 1972*

2.3.1 International Environmental Agreements on hazardous substances management.

After having read the previous section it is noticed the many international efforts focused on promoting better managing of chemical substances, including all stages of its lifecycle. The meetings held with this purposes have many times resulted in the creation of international agreements, which have to be signed, approved and ratified or accessed in order to enter into force and have an effective impact on each countries environmental legal framework.

The introduction of these agreements is a result of the increasing international trade in which chemicals play an important role for the economic development of a region. The international exchange dependency of many countries have forced the implementation of regulatory frameworks to establish precautions, responsibilities, safe conditions on handling, transporting, classification, packaging, labelling, storage, among other aspects, related with hazardous substances appropriate handling. Table 2.6 resumes some international agreements by year of adoption, and when available, information of German and Mexican legal binding.

Table 2.6 *International Agreements on matter of hazardous substances management of Germany and Mexico.*[3]

AGREEMENT / TREATY	CREATION LOCATION/YEAR	DATE IN FORCE	IMPLEMENTATION STATUS	
			Germany	Mexico
European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)	Geneva, 1957	1968	Approved	N.A.[1]
FAO - International Code of Conduct on the distribution and use of Pesticides	Rome, 1985	1985	Approved	Approved
Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal	Basel, 1989	1989	Signed 2002	N.I.
Convention on Civil Liability for Damage Caused during Carriage of Dangerous Goods by Road, Rail, and Inland Navigation Vessels (CRTD)	Geneva, 1989	*Not in force*	Signed 1990	N.I.
Convention on the Transboundary Effects of Industrial Accidents	Helsinki, 1992	2000	1998	N.A.
Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade	Rotterdam, 1998	2008	1998 / 2001r	2005a
European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways (AND)	Geneva, 2000	2009	2009-2011[2]	N.A.
Stockholm Convention on Persistent Organic Pollutants.	Stockholm, 2001	2004	2002	2003
Globally Harmonized System of Classification and Labelling of Chemicals (GHS)	UNECE, 2001	2005	2009	2009[3]

N.A., Not applicable / N.I., No implementation / s, signed/ r, ratified/ a, accessed
[1] *ADR is a UN Model based, which influences national regulations*
[1] All EU Member States shall implement the AND from July 2009 to June 2011
[1] NOM adaptation; ANIQ has promote GHS standards since 2002

[3] *Information from: European Commission, 2010; FAO, 1985; Misión Permanente de México, 2008; Rotterdam Convention Secretariat, 1998; Secretariat of the Stockholm Convention, 2008; UNECE, 1992, 2000, 2009, 2010; UNECE, n.d.; UNEP, n.d.*

2.3.2 Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

In this section is further detailed the GHS, since it is one of the most recent and relevant international contributions on matter of hazardous substances management, acknowledging also its impact on national regulations.

Due to the rapidly increase on international chemicals trade, an adequate classification and labelling system of hazardous substances has been a complex issue over time. For this reason the United Nations Economic Commission for Europe (UNECE) has created the "Globally Harmonized System of Classification and Labelling of Chemicals (GHS)", which: *"addresses classification of chemicals by types of hazard and proposes harmonized hazard communication elements, including labels and safety data sheets. It aims at ensuring that information on physical hazards and toxicity from chemicals be available in order to enhance the protection of human health and the environment during the handling, transport and use of these chemicals…it also provides a basis for harmonization of rules and regulations on chemicals at national, regional and worldwide level, an important factor also for trade facilitation."* (UNECE, 2010).

As a result from the Plan of Action adopted in Johannesburg on 4 September 2002, the World Summit on Sustainable Development encouraged countries to implement the GHS as soon as possible with a view to having the system fully operational by 2008.

This system establishes differences between the types of hazards that a dangerous substance or mixture represents: physical hazards, health hazards and environmental hazards. The basic classification of hazardous substances according to the first revision of this GHS document is shown on Table 2.7.

Table 2.7 *Basic Classification of Hazardous Substances according to the Global Harmonized System (UNECE, 2010) .*

PHYSICAL HAZARDS	
1. Explosive	10. Pyrophoric solid
2. Flammable Gas	11. Self-heating substance or mixture
3. Flammable Aerosol	12. Substance or mixture which in contact with water emits flammable gas
4. Oxidizing Gas	13. Oxidizing liquid
5. Gases under pressure	14. Oxidizing solid
6. Flammable Liquid	15. Organic peroxide
7. Inflammable Solid	16. Corrosive to metals
8. Self-reactive substance or mixture	
9. Pyrophoric liquid	
HEALTH HAZARD	
1. Acute Toxicity	6. Carcenogenicity
2. Skin Corrosion	7. Reproductive Toxicity
3. Serious eye damage/eye irritation	8. Specific Target organ Toxicity – Single Exposure
4. Respiratory or skin sensitisation	9. Specific Target organ Toxicity – Repeated Exposure
5. Germ cell mutagenicity	10. Aspiration Hazard
ENVIRONMENTAL HAZARDS	
1. Hazard to aquatic environment	

Nevertheless, this document has been revised and amended three times, from its first publication in 2003 to its third revised edition published in July, 2009. This last version, takes into account all past amendments as well as provisions for the allocation of hazard statements and for the labelling of small packaging; two sub-categories for respiratory and skin sensitization; the revision of the classification criteria for long-term hazards (chronic toxicity) to the aquatic environment; and a new hazard class for substances and mixtures hazardous to the ozone layer.

For the risk communication process, the GHS proposes the use of pictograms and symbols which can be resumed as shown in Figure 2.3.

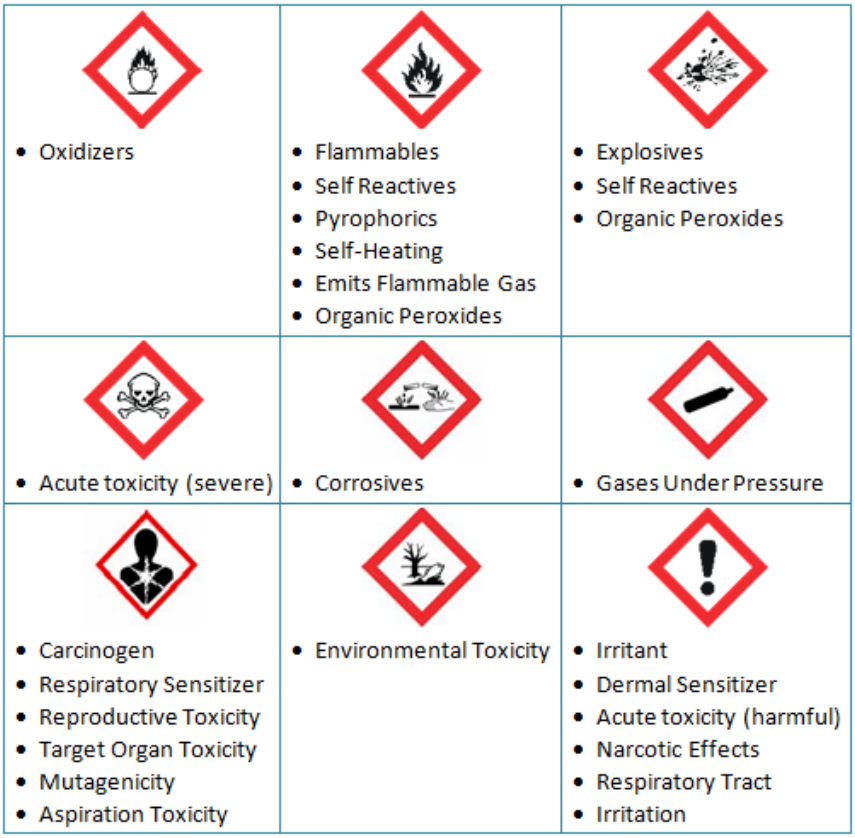


Figure 2.3 *GHS Pictograms and Hazard Classes (UNECE, 2010).*

This system is applicable to governments, regional institutions and international organizations, nonetheless it works as guidance for the worldwide industry, which will ultimately be implementing the requirements which have been adopted (UNECE, 2010).

At the present, the hazardous substances regulation on classification, packaging and labelling of dangerous substances in the European Union has been adapted, in order to be compatible with the GHS introducing the Regulation (EC) No 1272/2008 in force on December 2008, which would be further detailed.

On the other hand, in Mexico the adaptation process has not been yet completed. While the GHS has been taken into account into official transport regulation by the Mexican Ministry of Communications and Transportation, the developed norms only refers to substances, materials and waste classified as Explosives, officially named as the following:

- *NOM-009-SCT2/2009* - Establishes Special and compatibility specifications for the storage and transport hazardous substances, materials and toxic waste of Class 1 – Explosives.

Moreover, this norm published on February 2010 concurs with the first revised edition of the GHS, meaning that it doesn't consider the amendments presented on the third edition (SCT, 2009).

Apart from this, the National Association of the Chemical Industry (ANIQ) in Mexico promotes the GHS awareness and implementation in the industry, providing courses and explanatory documents that suggest its consideration (ANIQ, n.d.).

2.4 ENVIRONMENTAL REGULATIONS ON DANGEROUS CHEMICAL SUBSTANCES USE AND MANAGEMENT.

Since environmental law involves many different aspects, it is difficult to include all of them, even from only one country, in one single chapter.

Indeed, legal framework related to dangerous goods and so hazardous substances, is very extensive and covers different aspects as:

- national classification systems, frequently based on international models or guidelines;
- national lists that establish limits and considerations to identify hazardous substances;
- industrial responsibility, conditions of storage, use, and information diffusion obligation;
- packing, labelling and classification for transporting dangerous goods;
- discharge limits, after wastewater treatment, on drains or natural waterbodies;
- workers and work environment safety conditions; among others.

Therefore, this section intends to give a general framework in order to identify at least the most relevant laws in the German and Mexican framework issuing hazardous substances.

2.4.1 European Union Relevant Chemical Legal Instruments.

Recognizing the hazard that chemical substances represent for human health and environment, the European Union (EU) counts with a regulatory standardized framework for its Members States. This includes mainly four legal instruments that govern chemicals in the Community:

- ***Council Directive 67/548/EEC*** adopted on June 27th, 1967 on the approximation of the laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances;
- ***Council Directive 76/769/EEC*** of 27 July 1976 on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations;
- ***Directive 1999/45/EC*** of the European Parliament and of the Council of 31 May 1999 concerning the approximation of the laws, regulations and administrative provisions of the Member States relating to the classification, packaging and labelling of dangerous preparations; and,

- ***Council Regulation (EEC) No 793/93*** of 23 March 1993 on the evaluation and control of the risks of existing substances.

From these, the one of most interest based on its pursuit on protecting public health, particularly workers handling dangerous substances, is the CD 67/548/EEC.

The Council Directive 67/548/EEC is also known as the *Directive on Dangerous Substances* and has ruled since its adoption the dangerous chemicals substances management in the Member States of the EU, being also updated several times by the introduction of chemical substances released into the market.

The Directive's classification of dangerous substances places a substance into one or several defined classes of danger and characterizes the type and severity of the adverse effects that the substance can cause. The packaging of dangerous substances protects individuals from the known risks of a substance, and the labelling of hazardous substances provides information about the nature of the substance's risks and about the safety measures to apply during handling and use (Council of the European Economic Community, 1967).

This regulation excludes control of medicinal products, narcotics and radioactive substances; carriage of dangerous substances by rail, road, inland waterway, sea or air; and, munitions and objects containing explosive matter in the form of igniters or motor fuels.

This Directive adds four Appendixes with detailed information to achieve the sought purposes:

- *Appendix 1:* Index of dangerous substances.
- *Appendix 2:* Symbols and indications of danger for dangerous substances and preparations.
- *Appendix 3:* Nature of special risks attributed to dangerous substances and preparations.
- *Appendix 4:* Safety advice concerning dangerous substances and preparations.

The classification of hazardous substances, its symbols and description according to this regulation is organized on Table 2.8.

Table 2.8 *Hazardous substances classification by the Council Directive 67/548/EEC (Council of the European Economic Community, 1967).*

LETTER	CLASSIFI-CATION	DESCRIPTION	SYMBOL
E	Explosive	Those which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene	
O	Oxidizing	Those which give rise to highly exothermic reaction when in contact with other substances, particularly flammable substances	
F	Easily flammable	Those which may become hot and finally catch fire in contact with air at ambient temperature without any application of energy, or - solid substances and preparations which may readily catch fire after brief contact with a source of ignition, continue to burn or to be consumed after removal of the source of ignition, or - liquid substances and preparations having a flash point below 21°C, or - gaseous substances and preparations which are flammable in air at normal pressure, or - substances and preparations which, in contact with water or damp air, evolve highly flammable gases in dangerous quantities	
F+	Flammable	Those having a flash point between 21°C and 55°C;	
T	Toxic	Those which if they are inhaled or taken internally or if they penetrate the skin, may involve serious, acute or chronic health risks and even death;	
T+	Very Toxic	Those which in very low quantities cause death or acute or chronic damage to health when inhaled, swallowed or absorbed via the skin;	
C	Corrosive	Those which may, on contact with living tissues, destroy them;	
Xn	Harmful	Those which, if they are inhaled or taken internally or if they penetrate the skin, may involve limited health risks;	
Xi	Irritant	Non-corrosive substances and preparations which, through immediate, prolonged or repeated contact with the skin or mucous membrane, can cause inflammation.	
N *or/and* **R52, R53, R59;**	Dangerous for the environment	Those which, were they to enter the environment, would present or may present an immediate or delayed danger for one or more components of the environment.	
R42 *or/and* **R43**	Sensitizing	Those which, if inhaled or if penetrate the skin, are capable of eliciting a reaction of hypersensitisation such that on further exposure to the substance or preparation, characteristic adverse effects are produced.	*(No symbol)*
Carc. Cat. (1)	Carcinogenic	Those which, if they are inhaled or ingested or if they penetrate the skin, may induce cancer or increase its incidence.	*(No symbol)*
Muta. Cat. (1)	Mutagenic	Those which, if they are inhaled or ingested or if they penetrate the skin, may induce heritable genetic defects or increase their incidence.	*(No symbol)*
Repr. Cat. (1)	Toxic for reproduction	Those which, if they are inhaled or ingested or if they penetrate the skin, may produce, or increase the incidence of, non-heritable adverse effects in the progeny and/or an impairment of male or female reproductive functions or capacity	*(No symbol)*

2.4.1.1 Regulation (EC) No 1272/2008 or CLP Regulation.

As mentioned before, in 2003 the UNECE published the first revised edition of the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) as a result from the efforts different programs of the United Nations in collaboration with other international organizations with the main purpose of globally standardize the hazardous identification system.

In response of this, the European Parliament and the Council created and published on December 2006 the Regulation (EC) No 1907/2006, also known as the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). It established the creation of a European Chemicals Agency, amended Directive 1999/45/EC and repealed other related council and commissions directives.

Then, in December 2008, the European Council and Parliament published the Regulation (EC) No 1272/2008, also known as classification, packaging and labelling regulation or *CLP Regulation.* It amends the REACH and repeals in a transitional period Directives 67/548/EEC and 1999/45/EC (*REACH*, 2006).

This CLP Regulation takes into account all aspects on both mentioned directives, also classifies dangerous substances in a similar, but in wide extended way. It specifies methods on classifying dangerous substances, and uses mainly the same symbols proposed on the other past directives. Furthermore, it includes an additional Hazard Class, named: *Hazard to the Ozone Layer.*

Symbols and risk communication are the ones proposed by the GHS *(previously shown in Figure. 2.3)* which are very similar to the ones used in the CD 67/548/EEC, but the form is changed for a diamond, with white background and red boarder. Then two additional symbols are noticed relating to health hazard and the highest hazard category on different classes.

Nevertheless, it is worth mentioning that when translating from the Council Directive 67/548/EEC to this regulation, not all elements can be directly translated, leaving gaps in the process and appearing the legend *"No direct translation possible"* or *"No translation possible"* on the translation list included in the official document of this regulation (ECHA, 2009).

2.4.2 Important Regulations about Hazardous substances in Germany.

Related to environmental protection in Germany, it can be estimated about three thousand statements among laws, regulations, administrative provisions and technical regulations. Most of these are based on the European Union laws.

Following the European contracts, the State members transfer parts of their national legislative powers to the institutions created by these treaties.

With the primary collection of norms can be distinguished different forms of secondary norms, from which the regulations and guidelines which are significant for Environmental protection.

Moreover, while the regulations in the state members are direct effective laws, serving as guidelines for the State members to achieve their results, they leave to national authorities the forms and methods to carry them out (Kostka, 1997).

Figure 2.3 shows German Constitution organization relating environmental issues to take into account, dividing them as federal and state matters. As it is shown, environmental protection law is separate from what is referred to the chemical legislation, in which this section focuses and so it facilitates its study.

Nevertheless, it is worth mentioning that it does not mean that these laws have no relation, but they are connected by the Environmental Liability Law (*UmweltHG*) and Environmental Impact Assessment Law (*UVPG*) as shown in the diagram.

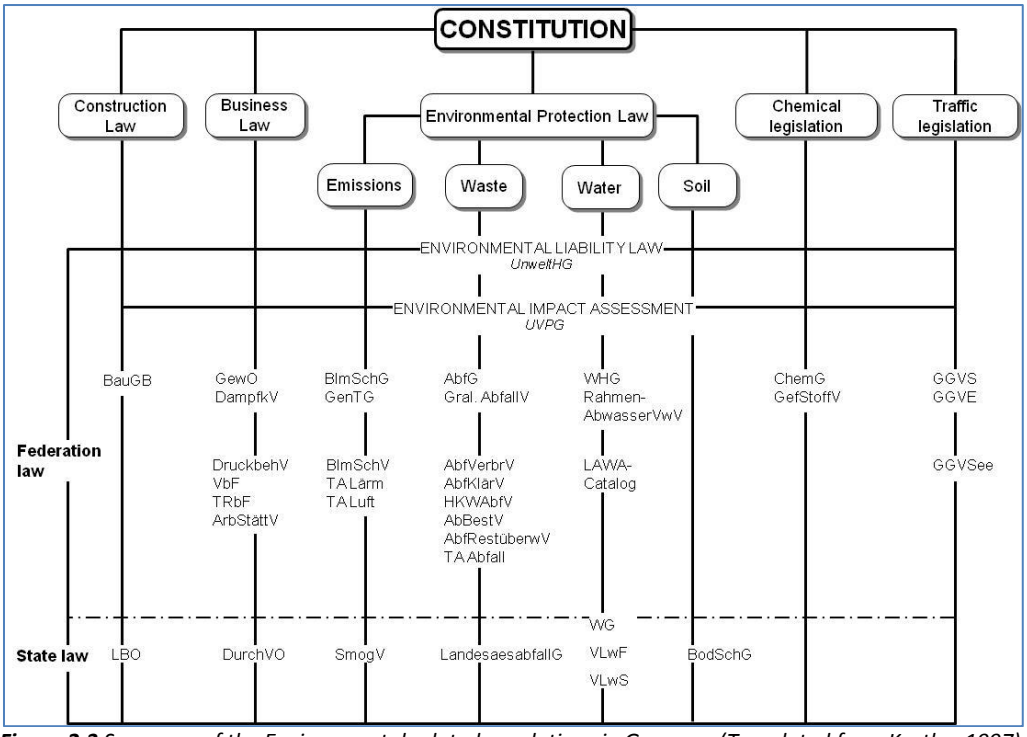


Figure 2.3 *Summary of the Environmental related regulations in Germany (Translated from Kostka, 1997).*

The Environmental regulations in Germany have their beginning around the 70's and since then they are guided by the following principles:

- ***Precautionary principle,*** becoming the model of the Environmental politic, i.e., by the setting of limits and conditions for construction and operation facilities according to Environmental Protection laws.
- ***Polluter pays principle (PPP),*** referring that the cost payments must be done by those who cause the impact. This principle is implemented through statements on environmental regulations and pollution fees.
- ***Cooperation principle,*** referring to the joint work between government and private companies, aiming for environmental protection, meaning also public involving on the environmental decision making process that may concern. This principle is exposed on § 9 UVPG Public inclusion (Law about Environmental Impact Assessment, *Gesetz uber die Ümweltverträglichtkeitsprüfung*).

Then, it is necessary to understand the German norm hierarchy in order to explain and discuss it legal framework conditions. In order to do this, Figure 2.4 gives an example of how is the German legal framework organized referring to atmospheric emissions. Then, in the following parts the Chemical Legislation and the Hazardous Substances regulations will be described.

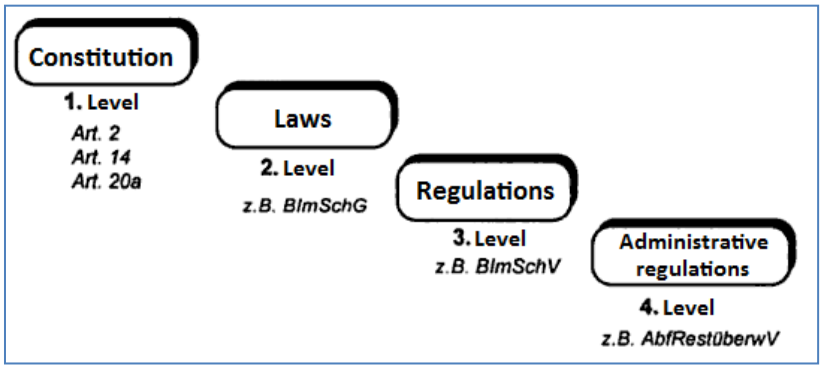


Figure 2.4 *German norms hierarchy for Atmospheric emissions (Translated from Kostka, 1997).*

2.4.2.1 Chemical Law – Chemikaliengesetz (ChemG).

The law on the protection from hazardous substances *(Gesetz zum Schutz vor gefährlichen Stoffen)* was first issued on September 1980 and last amended by June 2008. It is known as *Chemikaliengesetz, ChemG* or Chemical Act, and it aims to "... protect the people and the environment from harmful effects of dangerous substances and preparations" *(1§ ChemG).*

According to this law, hazardous substances or dangerous preparations are those with properties that can be identified as explosive; oxidizing; extremely, lightly or normally flammable; very toxic or just toxic; harmful; corrosive; irritant; sensitizing; carcinogenic; mutagenic or toxic to the environment (Kostka, 1997).

Then with "Environmentally dangerous" it refers to those substances or preparations which are capable to cause impact, by themselves or by their conversion products, on the natural properties of water, soil or air, climate, animals, plants or microorganisms, so that in the present or future induce danger on the Environment *(§3a Abs. 2 ChemG).*

Substances that fall under at least one of the above criteria, must be registered before they are marketed as such or in preparations *(§4 ChemG, Abs. I).* The declaration must be made including production information, use, exposure and disposal *(§§ 7, 9 and 9a ChemG).* The handling of these substances in the operation is regulated, particularly to protect the workers (Kostka, 1997).

The regulations on this law are guided by the Regulation (EC) No 1907/2006 of the European Parliament and of the Council, concerning the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH).

For substances notification or registration, REACH takes into account three important European lists:

- *ELINCS:* European List of Notified Chemical Substances (new substances),
- *EINECS:* European Inventory of Existing Chemical Substances (old substances),
- *NLP:* No-longer-polymers.

Other entries not listed in EINECS or ELINCS are designated using an internationally recognized chemical name (e.g. ISO, IUPAC). An additional common name is included in some cases. But in most cases, if a substance is not included in these lists, it means that it has not been sufficiently tested and / or there are no adequate empirical data. The same applies to the constituents of preparations. The new material must be registered and then goes through a series of fairly complex tests, including toxicology tests, etc (*REACH*, 2006). The law specifies a number of regulations, the most important are:

- *Test certification regulation, (Prüfnachweisverordnung, ChemPrüfV)* determining the application procedures to obtain substances required identification information;
- *Chemicals Prohibition Ordinance (Chemikalienverbotsverordnung, ChemVerbotsV)* with the list of substances and preparations prohibited on market;
- *Hazardous Materials Regulation (Gefahrstoffverordnung, GefStoftV)* with regulations on classification and on the labelling and packaging of dangerous substances, preparations and certain products. It includes also indication of use of dangerous substances.

Finally, due to the extensive use of chemicals in the industry, the *ChemG* is particularly important. The properties of chemicals and the way of dealing with them must be documented. The legally required documentation may be integrated into an environmental management system of the company.

2.4.2.2 Hazardous Substances Regulation – Gefahrstoffverordnung (GefStoffV).

The regulation for the protection against hazardous substances *(Verordnung zum Schutz vor Gefahrstoffen)* was first issued on December 2004 and last amended on December 2008. It applies to the marketing of substances, preparations and products, aiming to the protection of employees and other person's health and safety against risks from hazardous substances and to protect the environment from substance-related damage (*GefStoffV*, 2004).

On its second section, this regulation establishes the control on marketing and information of dangerous chemical substances. This section defines the different hazard terms related with dangerous materials. After that, it specifies the conditions and requirements of substances information exchange, like: classification, packing and labelling; and inclusion of the security data sheets. The substances this regulation refers exclude products identified as food or animal feed, and are:

- included on *§3 Abs. 1* of the *ChemG* in the version published on June 2002, and in its modified version, on Article 10 of the on May 2004;
- certain substances, preparations and products in accordance with the Directives 76/769/EEC, 96/59/EC and 1999/45/EC;
- biocide products as defined in *§3b, Abs. 1 No. 1* of the *ChemG*, which are not considered as dangerous substances or preparations within the meaning of *§3a* of the *ChemG*; and,
- biological agents, to be launched as biocide products on the market.

From the third to sixth sections it makes reference to the protection of employees' health and safety against actual or potential risks through effects from activities involving dangerous substances, preparations and products.

Then, these sections also apply to the transport of hazardous chemical substances and preparations. Without affecting the provisions of the Law on transport dangerous goods and the regulations based thereon.

It is also relevant to remark that this regulation does not apply for substances that are matter subject of the 1999 Regulation on Biological substances (*Biostoffverordnung*).This applies also to the applicability restriction to establishments under control by the last amendment of the Federal Mining Law in 2004 (*Bundesberggesetz*) (*GefStoffV*, 2004).

2.4.2.3 German Regulations on environmental release of chemical substances.

In the industry, chemicals substances use lead always to substances environmental release in low or high concentrations, which can be products and/or by-products from these activities. This means that all industrial activities cause environmental impacts which interfere with air, water and soil natural quality.

Therefore, referring to the legal framework to consider when dangerous chemical substances have been used by the industry, it is important to notice which legal instruments may apply in each country or even region where such activity is located. However, due mainly to the extension of these subject, those instruments will be only mentioned and listed according to the environmental impact to consider.

In the case of Germany it is important to mention that, since this country is a Member State of the European Union, the national regulations have to be consisted by those established by the Council and European Parliament.

INDUSTRIAL WASTEWATER DISCHARGES.

The regulations in Germany referring to Wastewater are summarized on the:

- Regulation of requirements for the discharge of Wastewater into Waterbodies *(Verordnung über Anforderungen an das Einleiten von Abwasser in Gewässer or Abwasserverordnung - AbwV).*

This regulation establishes different discharge limits according to the wastewater origin, resulting fifty seven different wastewater possible producers and each of these has its corresponding annex in the regulation, e.g. domestic, potato processing, breweries, among others. For this master study, the relevant annex to consult is:

- Annex 40. Metal working, metal processing *(Anhang 40 Metallbearbeitung, Metallverarbeitung)*

In the same time this regulation has different limits according to the type of process that the metal has been received, e.g. Electroplating, Pickling, Anodic oxidation, Burnishing, Galvanization, Hardening, PCB manufacture, among others (*AbwV*, 1997).

ATMOSPHERIC EMISSIONS.

Although atmospheric emissions are not being deeply considered on this Master Study, it is relevant to mention that they must be considered on the company's regulations to comply and therefore included on its EMS. In the case of Germany the:

- First General Administrative Regulation Pertaining the Federal Immission Control Act *(Erste Allgemeine Verwaltungsvorschrift zum Bundes–Immissionsschutzgesetz)*

and more specifically the:

- "Technical Instructions on Air Quality Control" *(Technische Anleitung zur Reinhaltung der Luft – TA Luft)*

is the one that industrial companies have to comply regarding limits for air pollutants emissions like carbon monoxide, Nitrogen monoxide and dioxide, among other greenhouse gases (*TA Luft*, 2002).

2.4.3 Important Regulations about Hazardous substances in Mexico.

Among the Mexican organizations involved in the surveillance and establishment of appropriate handling of hazardous substances can be mentioned: The Ministry of Environment and Natural Resources *(Secretaría de Medio Ambiente y Recursos Naturales, SEMARNAT)*, the Secretariat of Labour and Social Welfare *(Secretaría del trabajo y Prevision Social, STPS)* and the Ministry of Communications and Transportation *(Secretaría de Comunicaciones y Trasnportes, SCT)*.

SEMARNAT is in charge of surveillance and promotion of guidelines as Environmental Risk Assessment, accident prevention programs approved by Ministries of Energy, Economy, Health and Work, besides the developing of an Environmental Risk National Insurance System. SEMARNAT is also in charge of imports and exports trades on hazardous substances, even if Mexico is only a transport route for this. Furthermore, SEMARNAT verifies company's compliance with their own Environmental Impact Manifesto including oil, iron and steel, chemical, paper, cement and electric industries.

Then SCT and STPS have, among other important national duties, the responsibility of establishing and revising the regulations related to safe transport of dangerous substances and workers health.

In the following sections some of the most relevant legal instruments that regulate hazardous substances management are shown, as well as the legal institution in charge of their surveillance.

2.4.3.1 High Risk Activities (HRA).

According to the agreement between the Governance and the Urban Development and Ecology Departments and with bases on what is stipulated on the Articles 5th Fraction X and 146th of the General Law on Ecological Balance and Environmental Protection (LGEEPA); Article 27th Fraction XXXII and 37th Fractions XVI and XVII of the Organic Law on Federal Public Administration, two list issuing High Risk Activities are being published on the Federal Official Gazette *(Diario Oficial de la Nación)*.

Therefore, by Mexican regulation all activities that involve hazardous substances over-passing the "report quantity" are classified as "high risk activities" and they can be resumed as follow (Anglés-Hernández, 2006):

- A first list, published on March 28th, 1990 refers in its Article No. 3 to activities involving substances classified as toxic, meaning the ones that may impact on leaving organisms as

damage, diseases, genetic implications or dead. This includes around 830 hazardous substances, excluding pesticides (*Primer Listado de Actividades Altamente Riesgosas*, 1990).

- A second list, published on May 4th, 1992 which refers to inflammable and explosive substances; meaning with inflammable to those substances able to mix with air in such concentrations that may catch fire spontaneously or due to any spark; and meaning explosive those substances that spontaneously or through any form of energy generates intensive heat and energy pressure almost instantly. This list includes about 340 regulated hazardous substances (*Segundo Listado de Actividades Altamente Riesgosas*, 1992).

In both cases the "report quantity" refers to the minimum quantity of such hazardous substances that during production, process, transport, storage, use or final disposition (or the sum of all this) inside the work buildings or transport vehicles, that when escape, due through natural or human reasons, may cause a significant impact on the environment, population and well being on the surroundings.

2.4.3.2 General Law on Ecological Balance and Environmental Protection (LGEEPA).

The LGEEPA *(Ley General de Equilibrio Ecologico y Proteccion al Ambiente)* mention on its Article 23th and 148th the establishment of "middle safety zones" which prohibits their use as residential or urban zones. Subsequently, Article 145th requires to obtain a special land use permission for the establishment of industrial parks with HRA, for which is also stipulated to realize an Environmental Impact Assessment (EIA) and an Environmental Risk Assessment (ERA) on articles 28th and 147th respectively. Additionally it I also required that companies with HRA count with an Environmental Risk Insurance (*LGEEPA*, 1988).

The existence of the ERA is revised and it must include the following components:

- Distribution map of the different areas of process, storage, utilities, offices, etc.
- Detailed description of the processes (flow charts).
- Raw Materials, Products and By-products (storage capacity).
- Materials Safety Data Sheets (MSDS)
- Waste of major production control (characterization, control systems and technologies, treatment and final disposal)
- Operating conditions (extremes temperatures and pressures of operation, physical state of the different processes' stages)
- Piping and instrumentation plans.
- Identification and Prioritization of Risks by applying an adequate methodology.

The LGEEPA is being used as a base for national official norms for handling, storage, transport, reuse, recycling, treatment and final deposition of hazardous substances.

2.4.3.3 General Law for Waste Prevention and Comprehensive Management (LGPGIR).

Since one of the most important parts of the hazardous substances life cycle is the generation of toxic dangerous waste, it is of great importance for all countries that includes an environmental legal policy to count with special regulations on the subject.

Hazardous Waste Regulations have been established in Mexico since November 25, 1988 including about 63 sections that regulate the generation, handling, import and export, control and safety, and sanctions applicable to hazardous wastes. The applications of such sanctions are responsibility of the Federal Executive through SEMARNAP *(Art. 150-153, Environmental Act).*

In Mexico, the LGPGIR *(Ley General para la Prevención y Gestión Integral de los Residuos)*, last modified on June 19th, 2007 includes special management for dangerous waste, which must be safe and environmentally adequate.

According to this law some important factors to be considered for the appropriate management of this dangerous waste are: handling capacity and quantity, toxic substances persistence, mobility, bioavailability, duration and intensity of exposition and living organism's vulnerability against them. From this law, are being considered as dangerous waste the following (*LGPGIR*, 2007):

- Used lubricating oils;
- Used organic solvents;
- Vehicles catalytic converters;
- Motor Vehicle Batteries containing lead;
- Electric batteries that contain mercury or nickel-cadmium;
- Fluorescent and mercury vapour lamps;
- Additives containing mercury, cadmium or lead;
- Drugs;
- Pesticide containers containing remnants of the same;
- Persistent organic compounds such as polychlorinated biphenyls;
- Oil-based drilling mud, extraction from fossil fuels and sludge from sewage treatment plants (when considered hazardous);
- Blood and derivatives (only in liquid form);
- Pathogens strains and crops generated from diagnosis and research procedures and from biological agents production and control;
- Pathological waste consisting of tissue, organs and parts that are removed during autopsies, surgery or some other type of surgery that are not contained in formalin, and
- The sharp-pointed objects as waste that have been in contact with humans or animals or their biological samples for the diagnosis and treatment, including scalpel blades, lancets, syringes with integrated needle, hypodermic needles, acupuncture and tattooing.

In this law is also specified that companies that generates this kind of waste must notify it to the SEMARNAT and report generation quantities and documents that prove their proper management

and disposal. It is also stipulated that one type of dangerous waste must not be mixed with other types of waste or materials in order to avoid contamination and chemical reactions.

Temporal storage for dangerous waste must not overpass six months since generation, bottles or containers are also considered dangerous waste, even if empty.

In case that the waste treatment is done inside the company, it must be authorized and reported to the SEMARNAT including procedures, methods and techniques. The release into the environment must assure prevent, reduce and control the release of toxic substances into the environment. Treatment can also be done by other companies authorized by the SEMARNAT.

In case of transportation of dangerous waste it is important to take into account some prevention measures to avoid escapes, leakages or release into the environment of these substances.

The LGPGIR prohibits also dilution as an "option" to reach allowance limits of confinement, as well as incineration of dangerous waste that contain persistent organic compounds or bioaccumulable substances, organochlorine pesticides, used batteries and accumulators that contain toxic heavy metals, as long as there exist in the country another available technology that may represent less risk and environmental impact (*LGPGIR*, 2007).

2.4.3.4 Safety Work Conditions Regulations - Secretary of Labour and Social Welfare.

An adequate management of hazardous substances involves appropriate labour training and precaution measures in order to assure a safe work environment.

As mentioned before since Mexico joined the ILO, legal authorities increased their concern on labour health when exposed to hazardous substances. Therefore, several regulations were included into the Mexican law in order to persecute safety work conditions, from which can be mentioned:

- Federal Regulation on Safety, Health and the Workplace (RFSH).
- Federal Labour Law *(list of diseases linked with chemical agents)*.
- *NOM-005-STPS-1998.* Relative to health and safety conditions in the workplace for the handling, transport and storage of hazardous chemicals. D.O.F. 2-II-1999.
- *NOM-006-STPS-2000.* Materials handling and storage - Terms and safety procedures. D.O.F. 9-III-2001.
- *NOM-010-STPS-1999.* Health and safety conditions in workplaces where are handled, transported, processed or stored chemicals that can cause pollution in the working environment. D.O.F. 13-III-2000. (Elucidation and errata DOF 21-VIII-2000).
- *NOM-017-STPS-2008.* Personal Protective Equipment (PPE) - Selection, use and management in the workplace. D.O.F. 9-XII-2008.

- *NOM-018-STPS-2000.* System for identification and communication of hazards and risks posed by hazardous chemicals in the workplace. D.O.F. 27-X-2000. (Elucidation D.O.F. 2-I-2001).
- *NOM-025-STPS-2008.* Lighting conditions in the workplace. D.O.F. 20-XII-2008.
- *NOM-026-STPS-2008.* Colours and health and safety signs and identification of risks taken by fluids in pipes. D.O.F. 25-XI-2008.
- *NOM-028-STPS-2005.* Labour Organization, Process Safety of chemicals. D.O.F. 14-I-2005.

2.4.3.5 Mexican Regulations on environmental release of chemical substances.

During many of the different stages that a hazardous substances go through exist a potential risk of having a negative and irreversible impact on the environment due to conscious or unconscious release of substances into the environment, meaning the first atmospheric emissions and wastewater release, and the second ones meaning accidental leakages, spills or uncontrolled processes.

As mentioned before, due to the extension of these regulations, the legal instruments relating substances environmental release would only mentioned and listed according to the environmental impact to consider.

INDUSTRIAL WASTEWATER DISCHARGES.

The Mexican regulation system relating wastewater discharges is arranged according to the final destination or use of the treated wastewater and sludge that this process originates. Then for this master study, it would be important to take into account the limits established in the following norms:

- *NOM-001-SEMARNAT-1996.* Norm that establishes the maximum allowance limits of basic pollutants and heavy metals in wastewater discharges in national water bodies or national properties. First published on January 6th, 1997 and started in forced the next day.
- *NOM-002-SEMARNAT-1996.* Norm that establishes the maximum allowance limits of wastewater discharges in urban or municipal sewage systems. First published on January 3rd, 1998 and started in forced the next day.
- *NOM-003-SEMARNAT-1997.* Norm that establishes the maximum allowance limits for treated wastewater reused in public services. First published on September 21st, 1998 and started in forced the next day.

ATMOSPHERIC EMISSIONS.

As previously mentioned, atmospheric emissions are not been deeply considered on this research. Nevertheless their consideration is necessary for compliance of countries regulations by the company. In the case of Mexico, atmospheric emission limits are established according to the type of gases generators. Therefore the ones applicable to the study cases of this research are:

- *NOM-043-SEMARNAT-1993.* Norm that establishes maximum permissible levels of air emission of solid particles from stationary sources.
- *NOM-085-SEMARNAT-1994.* Stationary sources using fossil fuels solid, liquid or gas or any combination thereof. Maximum permissible levels of emission to the smog atmosphere, total suspended particles, sulphur dioxide and nitrogen oxides. Requirements and conditions for the operation of the equipment by indirect heating combustion as well as maximum allowable levels of sulphur dioxide issue in equipment for heating by combustion (Amendment 11-November -1997).
- *NOM-086-SEMARNAT-SENER-SCFI-2005.* Fossil fuels specifications for environmental protection.
- *NOM-121-SEMARNAT-1997.* Maximum permissible levels of air emission of volatile organic compounds (VOCs) from operations coating of body in new car plant, use multiple units of passengers and utility, cargo and light trucks as well as the method for calculating their emissions (Amendment 09-September-1998).

CHAPTER III.

ENVIRONMENTAL MANAGEMENT SYSTEMS AND THEIR EVALUATION

An Environmental Management Systems (EMS) can be understood as a collection of elements like: actions, procedures, organizational structure that aims to comply with an environmental objective in a organization. As a reference to this concept, the ISO14001 can be used as an example, defining the EMS as:

"part of an organization's management system used to develop and implement its environmental policy and manage its environmental aspects" (*DIN EN ISO 14001:2004*, 2009).

Many companies take international standard guidelines (e.g., ISO 14001 or EMAS) in order to develop, implement, manifest compliance with established requirements and maintain a functioning EMS. During this process they have to commit to an environmental policy, consider environmental impacts, and organize a well structured teamwork responsible for the EMS functionality, among other activities (Figure 3.1). In these cases, the company pursuits a public recognition for this management, and obtains an internationally valid certificate supporting the compliance with the chosen standard requirements.

Nevertheless, nowadays many organizations don't count with a documented Environmental Management Handbook, or an organized collection of documents and well-defined and structured team of people in charge of those activities, but it doesn't really mean an absence of an EMS.

In many countries, most of the companies must fulfil some legal environmental requirements in order to avoid payment of pollution fees, or also to prevent future costly (economical, environmental or human life risk) accidents. In behalf of this, companies keep some records; introduce workers training safety programs and emergency plans and wastewater treatment or end-of-pipe technologies to avoid over-passing legal limits values of pollution. All this can also be considered as part of the EMS of an organization, even if a proper or documented one does not exist.

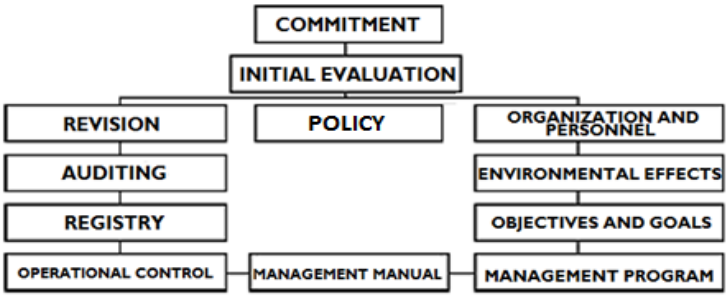


Figure 3.1 *Involved actions during EMS implementation (Modified from Comisión de Medio Ambiente y Recursos Naturales, 2000).*

Therefore, an EMS is part of the companies' organization sometimes without even been officially named as such. In many cases, in order to comply with authorities environmentally related requirements, several documents and records must be kept and handled at precise times (e.g., German and Mexican regulations, both specify records and reports to deliver to the corresponding agencies on the matter). A properly designed and documented EMS represents the companies' environmental care and integrates the legal requirements that must be fulfilled. Therefore, it considers activities as: activities' environmental impact, waste management, atmospheric emissions, and so on.

Subsequently, EMSs can be applied for any kind of organization that is aware about the impact that its activities have in the environment and the society. Therefore, integrate a sustainable management of its resources management that would *"meet the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987).*

The implementation of an EMS in any organization requires a deep knowledge on the activities that such organization carries out and a high commitment from all integrants no matter hierarchy since it is a program that includes all members of the organization *(Comisión de Medio Ambiente y Recursos Naturales, 2000)*.

The following sections will show the definitions and international guidelines that describe the concept of an EMS. Then, a special focus on the International Standard ISO 14001: 2004 is done, since this is the standard adopted by the company described in the study case of this research.

Finally, it is briefly explained how these systems can be evaluated by making use of specific assessment tools, which were useful to develop the proposed evaluation tool for EMS of hazardous substances (HS) in this research.

3.1 MAIN SCHEMES AND STANDARDS FOR EMS AROUND THE WORLD.

Since environmental self-regulation in the industry branch started to be of international concern, different guidelines describing the appropriate steps on environmental assessment were developed.

As expected, these standards had their beginning on developed countries; regarding the levels on industrialization and environmental impact that those activities represent. They were developed with the purpose of facilitate compliance with the national regulations that came up as result of international conferences with environmental concerns, e.g., the ones organized by the United Nations in Stockholm (1972) and Rio de Janeiro (1992).

Worldwide, there are a large number of standards, schemes and voluntary codes for EMSs. They all set a group of requirements that the system has to meet in order to become certified (Holbrook, 2009), including the elaboration of systematic plan of actions, documents control, and so on. Therefore, they can be oriented to pursuit environmental goals of an organization or authorities.

The organization is able to obtain the called *third-party certification* only after an authorized auditor verifies that the organization has fulfilled all established requirements on the chosen guidelines.

There are two main EMS standards, both widely known and implemented in many companies of the industrial branch in different countries:

1. The British Standard Institute's BS 7750 - Specification for Environmental Management Systems (BSI, 1994) and the
2. International Standards Organization's draft ISO14001 - Environmental Management Systems (ISO, 1995)

The two most schemes that relate environmental management are (Holbrook, 2009):

1. The Eco-Management and Audit Scheme (EMAS), established by the European Council Regulation (EEC) No. 1836/93 allowing voluntary participation by companies in the industrial sector in the Community Eco-management and audit scheme (CEC, 1993; DoE, 1995) and the adaptation of this scheme into the
2. EC Eco-Management and Audit Scheme for UK Local Government (UK-EMAS) (DoE, 1995) for application in the public sector.

In this context and regarding the extension of this study, only three of the most worldwide known and applied guidelines are described, followed by an emphasis on the ISO 140001 standard, which comes to be the most popular, certified and implemented standard since its publication in 1996.

3.1.1 BS 7750 Standard.

Historically, the first guideline that came to establish environmental guidelines for industrial practices was the British Standard (BS) 7750, which arose from a 1990 request to the British Standards Institute (BSI) for the development of third-party environmental verification through an auditing system.

Nevertheless, the release of the BS 7750 into the industrial market started with low acceptance, due to the relatively recently developed and implemented BS 5750, a quality standard that later evolved into the international standard ISO 9000. Companies were reluctant to include more costs on what seemed to be a whole different quality management standard (Wenk, 2005).

The BS 7750 standard was published in April of 1992 under the official title "BS 7750 Environmental Management Systems", it was revised and after two years of implementation reissued on January 1994, it is described as the first formal system implemented on any level—locally, nationally or globally. Referring to this, Rothery, B. (1993) recalls that:

"all those companies currently affected by environmental legislation and regulations… [BS 7750] will help such companies control their operations, maintain them within the regulations and demonstrate conformance with those regulations" (Rothery, B., p.4, 1993; cited in Wenk, 2005).

In this context, the BS 7750 was the first to provide companies a management framework to take self-defined steps and evaluate their practices from an environmental standpoint (Wenk, 2005).

The compliance with BS 7750 is voluntary for companies; nevertheless, its elements require compliance to statutory legislation ("BS7750," 2006). This standard is now designed to be compatible with the European Community's Eco-Management & Audit Scheme (EMAS) and also with International Standard ISO 14001.

An environmental policy supported by senior management and its clear description to the staff and to the public of how the company is complying the legal requirements, is one of the most important remarks of BS 7750 ("BS7750," 2006).

According to the BSI the international standard ISO14001, published two years later and from which creation the BSI was also participate, was derived from the BS7750.

On the other hand, there is a large discussion on similarities and differences among BS7750, ISO14001 and the Eco-Management Audit System. This discussion has derived on managers questions like, *how to choose an appropriate standard?* Question that brings up other issues to analyze, like: *Which standard represents in fact an environmental responsible care? What is the difference on following an environmental scheme and a management standard? And which standard fits the best the companies' necessities?* Many different experts on the topic have given their own points of view.

In order to answer those questions it is important to understand first of all what differences are on the root concepts of such systems. According to Spedding, L., Jones, D. and Dering, C. (1993), BS 7750 is an environmental management system, while EMAS is an environmental protection system. In this context, Wenk, M.S. (2005) remarks that the first one centres its attention on controlling, or managing, environmental effects without implying improvement or proactiveness; while the second one allows (or mandates) the environmental protection against further harm.

3.1.2 European Union Eco-Management and Audit Scheme (EMAS).

At the present time, EMAS is one of the central guidelines on the European Union to certify environmental responsible care. It is described by the European Commission as:

"a management tool for companies and other organizations to evaluate, report and improve their environmental performance" (European Commission, 2010).

Then, EMAS has its root probably from various European environmental auditing programs such as BS7750, Ireland (I.S. 310), France (X30-200), and Spain (UNE 77-801.2), (Wenk, 2005).

This standard available for voluntary participation, originally restricted to companies in industrial sectors in 1995 (EMAS I), was in 2001 open to all economic sectors, including public and private sectors (EMAS II), this version integrated also the standard DIN EN ISO 14001, recognized by the European Commission on 1996 as containing the basic requirements of an EMS, thus the ISO certified companies would just need to comply with three additional steps for the EMAS registration explained on Figure. 3.2.

Also by 2001, the EMAS logo was also created and used to distinguish the Community's members. Nevertheless, it is important to remark that the EMAS adds four important requirements to the ISO 14001 standard, Figure 3.3 (European Commission, 2010):

1. Employee involvement;
2. Public information through annual reporting;
3. Continual improvement of environmental performance;
4. Compliance with environmental legislation ensured by government supervision.

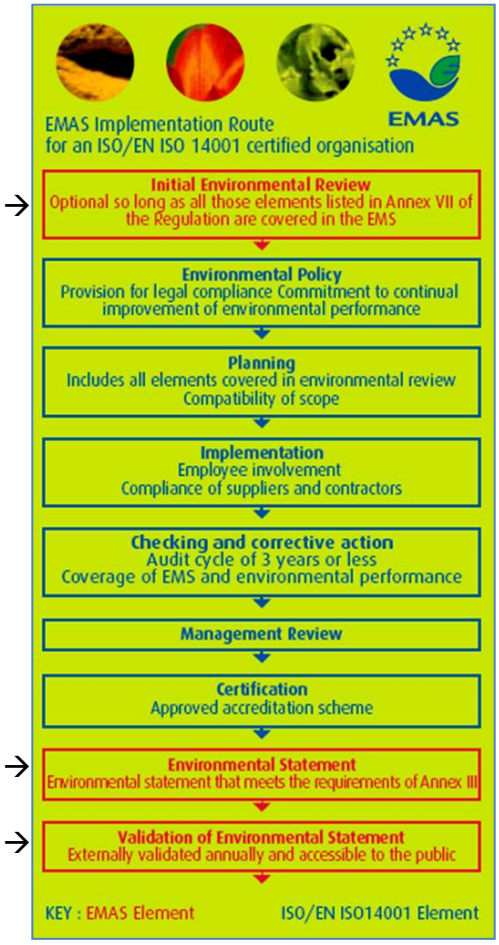


Figure 3.2 *From ISO implementation to EMAS registration. Step added to integrate both systems are signalized with a →* *(European Commission, 2008).*

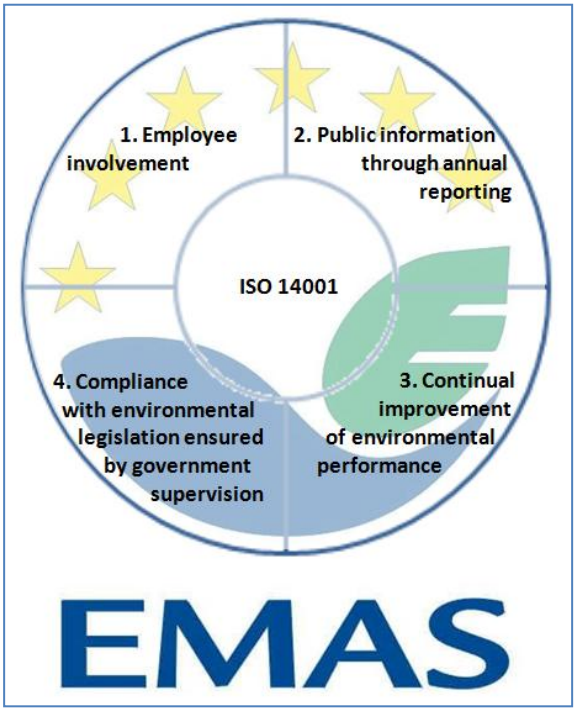


Figure 3.3 *Eco-Management and Audit Scheme requirements. (European Commission, 2010).*

The last revision and modification of the EMAS was done in 2009 and resulted in the Regulation (EC) No 1221/2009. Consequently, EMAS III was published on 22 December 209 and entered into force on January 2010, with modifications on improvement of applicability of the scheme and strengthening is visibility and outreach.

On the other hand, it is worth to remark differences between the EMAS system and ISO 14001, described on Table 3.1. This demonstrates in which aspects the EMAS goes beyond the ISO 14001 on the environmental management.

Table 3.1. *Difference between ISO/EN ISO 14001 and EMAS (European Commission, 2008).*

	EMAS	ISO / EN ISO 14001:2004
Status	Under legal bases (EU Member States and EEA countries). Regulation of the European Parliament and the Council under public law	Not under legal bases. (International: worldwide) ISO standard under private law.
Organization	The entity to be registered shall not exceed the boundaries of the Member State, and it is intended to go towards entities and sites	Does not go towards entities or sites
Environmental policy	Included commitment to continual improvement of environmental performance of the organization.	Does not include a commitment to the continual improvement of environmental performance but of the performance of the system
Initial environmental review	Obligatory preliminary review, when is the first time that the organization sets its environmental status	Initial review is recommended, but not required
Environmental aspects	Identification and evaluation of the environmental aspects (direct and indirect). Establishment of criteria for assessing the significance of the environmental aspects	Required only a procedure able to identify environmental aspects
Legal compliance	Obligatory to demonstrate it. Required full legal compliance. There is a compliance-audit	Only commitment to comply with applicable legal requirements. There is no compliance-audit
External communication	Open dialogue with the public. Public Environmental Statement (validated for verifiers)	Not open dialogue with the public. Only is required to respond to relevant communication from external interested parts. Control by public is not possible
Continual improvement	Required annual improvement	Required periodically improvement without a defined frequency
Management review	Is wider and requires an evaluation of the environmental performance of the organization, based in a performance-audit	Required an environmental performance in the management, but not through a performance audit
Contractors and suppliers	Required influence over contractors and suppliers	Relevant procedures are communicated to contractors and suppliers
Employees involvement	Active involvement of employees and their representatives	No
Internal environmental auditing	Includes: system-audit, a performance-audit (= evaluation of environmental performance) and an environmental compliance-audit (= determination of legal compliance)	Included only system audit against the requirements of the standard
Auditor	Required the independence of the auditor	Advised the independence of the auditor
Audits	Check for improvement of environmental performance. Frequency required: 3 year cycle during which all areas are verified at least once	Check environmental system performance. No frequency required
External verification	Accredited environmental verifiers	No
Verification/ Certification Scope	Verifiers accredited according to NACE codes	Certifiers accredited according to EAC code
Authorities are informed	Obligation by Validation of Environmental Statement	No obligation
Logo	Yes	No

3.1.3 International Standard - ISO 14001.

In 1992, the United Nations invited the International Standards Organization (ISO) to formally take part in the Earth Summit. Then, the Technical Committee ISO/TC 207 (1993) was created with the main objective to develop the ISO 14000 series of Environmental Management Systems, published in 1996.

The ISO 14000 series is a family of standards and guidelines that deal with environmental management. These standards can be classified according to their focus in two categories: (a) organization or process norms and (b) product oriented norms.

From this, the only descriptive standard is the ISO 14001, which is a specification standard, setting a model for EMS structure. Therefore, industrial companies around the world do not get certified on ISO 14000, but to ISO 14001 if their EMS complies with its established requirements.

ISO 14001 is a process oriented standard, not a product oriented, and its certification do NOT indicates an environmentally adequate product, but an environmental management system that is implemented and consistent.

According to its statements, its overall aim is to support environmental protection and prevention of pollution in balance with socio-economic needs. It intended to be applicable for all types and sizes of organization and accommodates diverse geographical, cultural and social conditions.

Additionally, it contemplates that the compliance with its requirements enables an organization to develop and implement a policy and objectives which take into account legal requirements and significant environmental aspects.

The success of the system would depend on the commitment from all levels and functions of the organization, and especially from top management. Then, apart from establishing environmental elements on their organization, the document control would allow the organization to demonstrate the conformity with this standard.

This International Standard is based on the methodology known as Plan-Do-Check-Act (PDCA) shown on Figure 3.4, which can be briefly described as follows.

1. *Plan:* establish the objectives and processes necessary to deliver results in accordance with the organization's environmental policy
2. *Do:* implement the processes
3. *Check:* monitor and measure processes against environmental policy, objectives, targets, legal and other requirements, and report the results.
4. *Act:* take actions to continually improve performance of the environmental management system.

A second edition was published on 2004, referred as ISO 14001:2004, which introduces some changes to ISO 14001:1996, even though it does not add elements to control, it is more descriptive

with those already established letting the organization to have more control over some EMS's elements, and add some requirements in order to improve information control and revision by implementing more documented procedures and input elements on the Management review stage, among others (CSA Technical Committee on Environmental Management Systems, n.d.).

On July 2009, the ISO14001:2004 edition has been modified to address and correspond to the last amendment on ISO 9001:2008 on Quality Management Systems. This version is identified as ISO 14001:2004/Cor 1:2009.

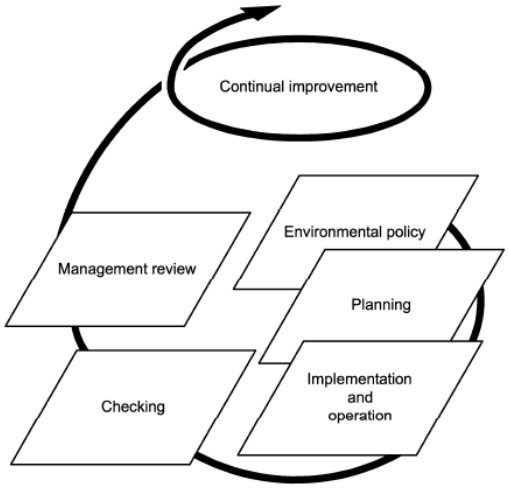


Figure 3.4 *ISO 14001 Methodology Plan-Do-Check-Act, PDCA (DIN EN ISO 14001:2004, 2009).*

In comparison with British Standards and EMAS, ISO 14001:2004 has been preferred among all the countries, even in the European Union. The reason for this lays on different elements, especially lower cost due to less time and human resources for implementation, then also fewer requirements to comply, e.g., environmental reporting to the public, and just an annual external audit. These reasons make ISO 14001 accessible to small and medium enterprises.

Furthermore, ISO 14001 is a worldwide recognized standard and that supports any organization that intends to introduce itself in the global market, that becomes more difficult for those companies registered in EMAS which is only recognized in the European Union and unfamiliar or unaccepted by non-EU countries (Whitelaw, 1997; cited in Chen, 2004).

Finally, the ISO 14001 requirements, statements and implementation guidelines are easily available on the internet and quality publications, there are a large number of consultant companies and auditors specialized in the subject, and many studies have been done on this subject. All this makes ISO 14001 a very accessible management tool and many companies, even those that are not certified, take this standard as a base for their EMS.

On the other hand, the ISO 14001 standard has been regularly criticized, regarding that it does not assure legal compliance due to its non-legal and non-obligatory condition. Then, another important short come is that it does not measure environmental performance of a plant or company (Krut and Gleckman, 1998); therefore, its continuous improvement cannot be assessed.

Although, this standard assumes that if implemented effectively it would lead to continuous environmental performance improvement, it is being argued that this is not recommendable (Rondinell, 2000), and that external verification is needed. Table 3.2 lists some other limitations of ISO 14001 standard (citations from Chen, 2004).

Table 3.2 *Potential limitations of ISO 14001 (Yarnell, P., 1999).*[4]

POTENTIAL LIMITATIONS OF ISO 14001
1. Difficulty interpreting terms such as *"environmental aspects"* and those *"over which it can be expected to have an influence"* from the company's activities.
2. Reliability from third-party auditors.
3. Measuring environmental performance is not done, only conformance to the EMS.
4. Costs of implementation can be too high for small and medium-sized organizations.
6. Varying international rigor of environmental laws and enforcement may lessen the utility of the standard
7. Increase on environmental responsibility is not necessarily related with improvement on documentation control.
8. Change resistance frequently occurs within organizations and presents barriers to implementation

3.1.3.1 General Requirements of ISO 14001:2004.

From its first publication in 1996, general requirements of ISO 14001 have not been widely change as explained before. Nevertheless, one of the most remarkable changes introduced in 2004 was the need to define and document the EMS scope, meaning an overall goal of the organization EMS that shall define the organization's Environmental Policy (EP).

The EP must be defined, documented and communicated in the EMS handbook, and for its development should be taken into account: (a)nature, scale and environmental impacts of the company's activities, products and services; (b)commitment to continual improvement; (c)pollution prevention; (d)compliance with legal and other requirements. Then it would be used as a framework to set objectives, targets and programs for the EMS implementation.

It is then the company's scope and EP the ones that drive the EMS functioning, based on the ISO14001:2004 standard; after this, the other requirements functioning follow the PDCA methodology. A brief resume of those requirements and its explanations can be found in Table 3.3.

[4] *Adapted from: Abbott 1997, BATE 1996c, Bell 1997, Bisson 1995, Boiral and Sala 1998, Gleckman 1996, Gleckman and Krut 1997, Hamner 1996, Hornal 1998, Lamprecht 1997, Lewis 1996, Powers 1995, Puri 1996, Sasseville et al. 1997, Todd 1994, Voorhees and Woellner 1998.*

Table 3.3. *ISO 14001:2004 Requirements description (DIN EN ISO 14001:2004, 2009).*

ENVIRONMENTAL POLICY	
Short statement that establish compliance with legal and other requirements, prevention of pollution, and continual improvement.	
PLANNING	
• **Environmental Aspects**	Significant aspects and related impacts that the organization can control or have influence over.
• **Legal and Other Requirements**	Those that pertain to organization operations and activities.
• **Objectives, Targets, and Programs**	Must be measurable and consistent with policy. Inclusion of Management programs (MPs) to reach targets.
IMPLEMENTATION AND OPERATION	
• **Resources, roles, responsibility and authority**	Defined management and structure; establish roles and responsibilities; choose of a Management Representative.
• **Competence, Training, and Awareness**	Education, training, and experience; Training records; Awareness on requirements, benefits, consequences of non-conformances, policy and emergency response.
• **Communication**	Internal and external; degree of openness and disclosure of information is decided by the organization, but the decision need to be documented.
• **Documentation**	In electronic or paper form; just need to include procedures that allow verification, as minimum: EMS scope, environmental policy, objectives and targets, related records.
• **Control of Documents**	Distribution control, identification of changes and availability of approved, revised and updated current versions. Prevent use of obsolete versions.
• **Operational Control**	Procedures and work instructions to proper execution of activities, also communicating applicable system.
• **Emergency Preparedness and Response**	Plans for mitigation and identification of emergency potential, involving if practicable periodic testing
CHECKING	
• **Monitoring and Measurement**	Use of measurements to provide data for action.
• **Evaluation of Compliance**	Periodic and recorded verification of applicable legal and other requirements.
• **Non-conformances, Corrective and Preventive Action**	Situation not in accordance with planned, corrections shall address root causes then evaluate trends in corrective actions to implement preventive actions.
• **Control of Records**	To verify system operation shall maintain procedure(s) for the identification, storage, protection, retrieval, retention and disposal of records
• **Internal Audit**	Including methodologies, schedules, checklists and forms, and processes used to conduct the audits.
MANAGEMENT REVIEW	
Periodic top management revision to prove plans suitability, adequacy, and effectiveness, and include recommendations for improvement.	

3.2 METHODS AND TOOLS FOR EMS ASSESSMENT.

The last section explained the EMS characteristics focussing on the most common international guidelines used to implement and maintain such systems. Nonetheless, it is worth mentioning that the EMS's main purpose is to count with a systematic and comprehensive system that helps the organization on having a controlled environmental management, and this can be done with or without being actually certified through these standards.

Then, after the EMS implementation, *how assure that the system actually works?* The answer is in the "Check" stage of the mentioned PDCA methodology, which includes periodic revisions that deliver the strengths and weak points of the system. The reliability of this step would facilitate the maintenance and functionality of the EMS.

Some assessment methods have been widely applied to determine environmental performance in organizations, like: Environmental Impact Assessment (EIA), Environmental Risk Assessment studies (ERA), Environmental Auditing (EA), compliance with national and/or international applicable regulations, and the use of Environmental Indicators of Sustainability (or self assessment indicators), among others.

Additionally, it is always important to take into account the expert's knowledge and advertising on the application and analysis of these methods. Their experience would guide on the data collection planning and monitoring programs, determine significance of environmental impacts and measures to prevent or minimize them.

Then, there are different kinds of assessment tools (e.g. checklists, matrices, sectoral guidelines) depending on the type of information that is needed, time available for the evaluation, the level of expertise of the evaluator and technological sophistication for their interpretation, among others. Therefore, take into account a descriptive criteria that guide into the selection of one of these tools could be useful. Lohani *et al* (1997) remark that the best methods for environmental assessment are those able to:

1. Organize a large mass of heterogeneous data;
2. Allow summarization of data;
3. Aggregate the data into smaller sets with least loss of information; and
4. Display the raw data and the derived information in a direct and relevant fashion.

It is worth mentioning that the Environmental auditing bases were taken into account for the development of the proposed evaluation method of EMS of HS in this research. Additionally, this method is supported also on the use of checklists, revision of applicable environmental regulations and indicators of environmental assessment explained in the following sections.

3.2.1 Environmental Auditing.

An Environmental Audit (EA) consists of a systematic and deep review of the organization structure and activities. It can be done firstly internal by qualified personnel involved in the EMS revision and maintenance programme, and then by the government or by certified environmental consulting firms. This evaluation aims to evaluate the compliance degree of such activities with the technical standards from legal and non-legal frameworks of environmental matter and subsequently detect possible risk situations in order to set preventive and corrective recommendations that may apply (PROFEPA, n.d.).

This technique became widely used in the early 1980s, initially within corporate structures to assure legal compliance and protect the corporation from legal liabilities, even sometimes involving either internal or outside engineering consultants to identify opportunities for cost-saving waste reduction.

Then, insurers and financial institutions began to inspect for environmental hazards as conditions of approving insurance coverage and loans. Subsequently, management system standards adopted it as a mechanism for avoiding the costs of shipment-by-shipment verification of product quality.

Finally, in EMAS and ISO 14000 standards EA is part of the basic requirements from a third-party certification to verify the performance and `continuous improvement' of EMS systems, even though environmental performance cannot be assessed on these baselines (Andrews, 2004).

Environmental Auditing can use different evaluation tools, which are commonly used also in methodologies of Environmental Impact Assessment, like checklists and evaluation matrix. Then it is important to remember that working personnel consultation through interviews may be of great value and deliver useful information, due to the communication process that must involve all employees in a formally established EMS. The following parts will define some useful evaluation tools involved with environmental auditing from which understanding is applicable on this master study.

3.2.1.1 Assessment Checklists and Matrices.

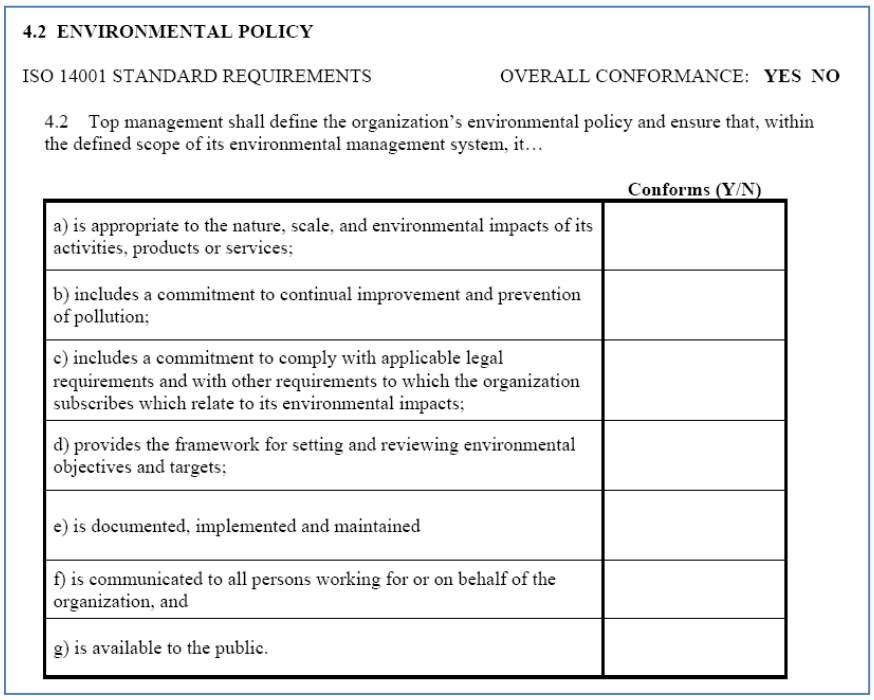
These assessment tools have been widely employed on EIA studies with the common purpose of organizing and presenting information, often considered as a positive starting point for analysis.

In general, they consist on list of questions or elements to study with their corresponding boxes or cells that shall be filled with information about the nature of the analyzed impact, meaning ‘a judgment value on the importance of a change measured through varied parameters and indicators’ (Rajvanshi, 2006). Then, depending on the type of checklist or matrix, this information can be descriptive or evaluative.

Complexity of those tools varies from the simplest, which merely determine the possibility or potential existence of an impact, to more complex and sophisticated ones that make judgments about the magnitude and importance of the impact (Lohani et al., 1997).

In this study research, the proposed evaluation method of EMS of HS can be considered as a combination of concepts of checklist, matrices and interviews. Though a deep explanation of the developed method is done on Chapter V, this section explains briefly its bases.

A *Checklist* can be defined as a standard list of the types of impacts associated with a particular type of activity. It has a primarily organization purpose or to ensure that no potential impact is overlooked. It lists the specific areas of impact and indicates the application instructions for impact identification and evaluation. As an example, Figure 3.5 shows a Simple checklist.



4.2 ENVIRONMENTAL POLICY

ISO 14001 STANDARD REQUIREMENTS OVERALL CONFORMANCE: **YES NO**

4.2 Top management shall define the organization's environmental policy and ensure that, within the defined scope of its environmental management system, it…

	Conforms (Y/N)
a) is appropriate to the nature, scale, and environmental impacts of its activities, products or services;	
b) includes a commitment to continual improvement and prevention of pollution;	
c) includes a commitment to comply with applicable legal requirements and with other requirements to which the organization subscribes which relate to its environmental impacts;	
d) provides the framework for setting and reviewing environmental objectives and targets;	
e) is documented, implemented and maintained	
f) is communicated to all persons working for or on behalf of the organization, and	
g) is available to the public.	

Figure 3.5 *Audit simple checklist example used for ISO 14001 Internal Audit (NSF-International Registrations, LTD., 2009).*

There are four general types of checklists (Lohani et al., 1997):

1. *Simple Checklist:* a list of environmental parameters with no guidelines on how they are to be measured and interpreted.
2. *Descriptive Checklist:* includes an identification of environmental parameters and guidelines on how to measure data on particular parameters.
3. *Scaling Checklist:* similar to a descriptive checklist, but with additional information on subjective scaling of the parameters.
4. *Scaling Weighting Checklist:* similar to a scaling checklist, with additional information for the subjective evaluation of each parameter with respect to all the other parameters.

On the other hand, *Matrix methods* identify interactions between various project activities and the environmental components that they may affect. In order to do so, it integrates both (activities

and environmental components) in a checklist that places the first one on the vertical axis and the other one on the horizontal axis. Interactions are evaluated by using subjective (expert) judgment, or by using extensive data bases, in order to fill the intersection cells in a similar way that it is done on a simple checklist; therefore, instructions are commonly indicated.

There are two general types of matrices: 1) simple interaction matrices; and 2) significance or importance-rated matrices. The main difference is that to prepare the second one it is required the use of extensive databases or experience.

Finally, the way on how those methods are going to be applied has to be considered when planning an Environmental Evaluation. The information needed can be obtained by simple observation, reports analysis or even personal interviews, when people is also affected by the evaluated activity (e.g. the community around a company or the own working personnel).

Therefore, some elements can be evaluated through interviews. Then the evaluator can follow a structured (or quantitative) interview, which has a semi-formal character similar to the ones used in surveys, using a standardized interview schedule. Nevertheless, depending on the type of information wanted, sometimes it is better to have a deeper perspective from the interviewee, then a combination with the "semi-structured" (qualitative, or "depth") interview may be required. Such are cases when it is important to take into account peoples' concerns that relate the environmental element to evaluate. Then the interview takes a more informal and conversational character, in order to pursuit validity and reliability on the respondents answers. However, the evaluator must be aware of possible sacrifice of standardization and repeatability between interviews (Cicourel, 1964; cited in Bloor & Wood, 2006).

In case of the proposed method for the evaluation of an EMS of HS, interviews are needed to grasp not only workers perception on risk awareness, but also workers involvement on the decision making process that relates the EMS.

In this context, the interviews should consider selected questions to evaluate the EMS's elements, risk awareness on HS management and workers point of view and concerns on this matter in order to take them into consideration for other opportunities of improvement and at the same time the self-improvement of the evaluation tool.

3.2.1.2 Official country's environmental regulations.

Compliance with official environmental country regulations is one of the main objectives of an EMS, for this reason the knowledge of the applicable norms has to be previously studied and described. Those norms, shall mention the documentation requirements, as well as permissions, environmental discharge and atmospheric emissions limits, toxic waste management and disposal, among others.

In order to revise the compliance with those regulations, each country has a responsible governmental institution that is in charge of verifying the fulfilment of the established requirements through different means, like: the Manifesto of Environmental Impact and Companies' annual reports on pollution control (e.g., wastewater discharges, atmospheric emissions, toxic waste management).

The present study takes into account the compliance of applicable regulations on Germany and Mexico regarding HS management in the industry, mentioned on Chapter II. These requirements have been taken into account by their inclusion as the environmental parameters to revise on the adapted checklists.

3.2.1.3 Indicators of environmental assessment.

By definition, an indicator is used to point, warn, manifest and show something. In other words, it is what people use to know the progress or change of something and frequently take decision on this matter. Therefore, almost all activities that involve a decision making process apply indicators, even if it is done in an unconscious way.

In environmental matters, indicators are defined as the group of parameters that are used to deliver information about the status of a phenomenon, environment or area, with a meaning that goes beyond the one directly associated with the parameter's value itself (González-Osorio et al, 2005).

There exist different types of indicators that can be used on Environmental Assessment, nevertheless it is important to have a clear and deep understanding on how they function and the information that they can deliver. For example, at national and international scale there are complex sustainability environmental indicators that are supported on conceptual frameworks to facilitate their clear and accessible interpretation, e.g., the commonly known Pressure – State – Response (PSR) proposed by the Environment Canada and the Organization for Economic Co-operation and Development (OECD, 1993; cited in González-Osorio et al., 2005).

Then, by industrial activity there can also be mentioned the *Sectorial Indicators*, which correspond also to a conceptual framework modified from the PSR developed by the OECD, and look for integrating established environmental sectorial policies according to the same industrial activity.

Finally, at a production plant level indicators must be adapted to the type of industry, particular production activities, regional environmental regulations and the own EMS objectives that the company pursuits. Therefore, many plants develop their own environmental indicators to evaluate the advances on the way of reaching goals and their improvements.

When those indicators are designed to evaluate the EMS performance, they are classified as Environmental Performance Indicators (EPI) and their use, interpretation and revision, though not

a strict requirement of ISO 14001, shall contribute to the continual improvement of the EMS in the company and maintain business relevance of the company's EMS.

These own plant's indicators are the ones taken into account on this master study, due to their mentioned function. In order to develop adequate EPI, Baxter, M. (2007) proposes that some issues must be taken into account, like:

- Recognize environmental costs and benefits for the organization.
- Determine other aspects of relevance for the organization or interested participants (lack of information availability, possible complains or demands).
- Develop measures of performance that are achievable (or already in use), and that accurately reflect the area of concern.
- Create simple and not confusing indicators to evaluate or communicate the information.
- Define actions required to implement data collection, concerning type of information, collection method, sources, times and responsible.
- Identify how indicator information will be used (e.g. auditing performance against targets), which would influence on the format to collect or present data.

CHAPTER IV.
EMPIRICAL WORK I.
INDUSTRIAL STUDY CASES DESCRIPTION

In this master academic study is proposed an evaluation tool that locates the environmental performance focusing on hazardous substances (HS) management on a descriptive environmental behaviour. Such evaluation is relevant for the industry in the present time, due to the continuous changes on regulatory international frameworks that have direct influence on national and local laws.

The proposed methodology has been applied on two study cases, one located in Germany and the other one in Mexico, both referring to industrial plants of the same company. Therefore, the same products and environmental policy is managed; however, there are found relevant differences on EMS performance according to the environmental legal framework they must be adapted to.

4.1 INTRODUCTION TO THE COMPANY: THYSSENKRUPP AG.

ThyssenKrupp AG (TK-AG) is a mayor industrial steel German company, globally expanded with almost 188,000 employees in more than 80 countries. All products and services provided by the company can be identified by the logo on Figure 4.1. From this, eight different business divide the company's activities, classified mainly in two business divisions: Materials and Technologies. Figure 4.2 resumes the company's coverage ("Group - ThyssenKrupp AG," 2009).

Regarding all different divisions, the study cases have been focused on two industrial plants of *ThyssenKrupp Bilstein Suspension GmbH*, part of the Components Technology Division on the business areas of ThyssenKrupp AG.

Figure 4.1 *ThyssenKrupp AG Logo (ThyssenKrupp AG, 2009).*

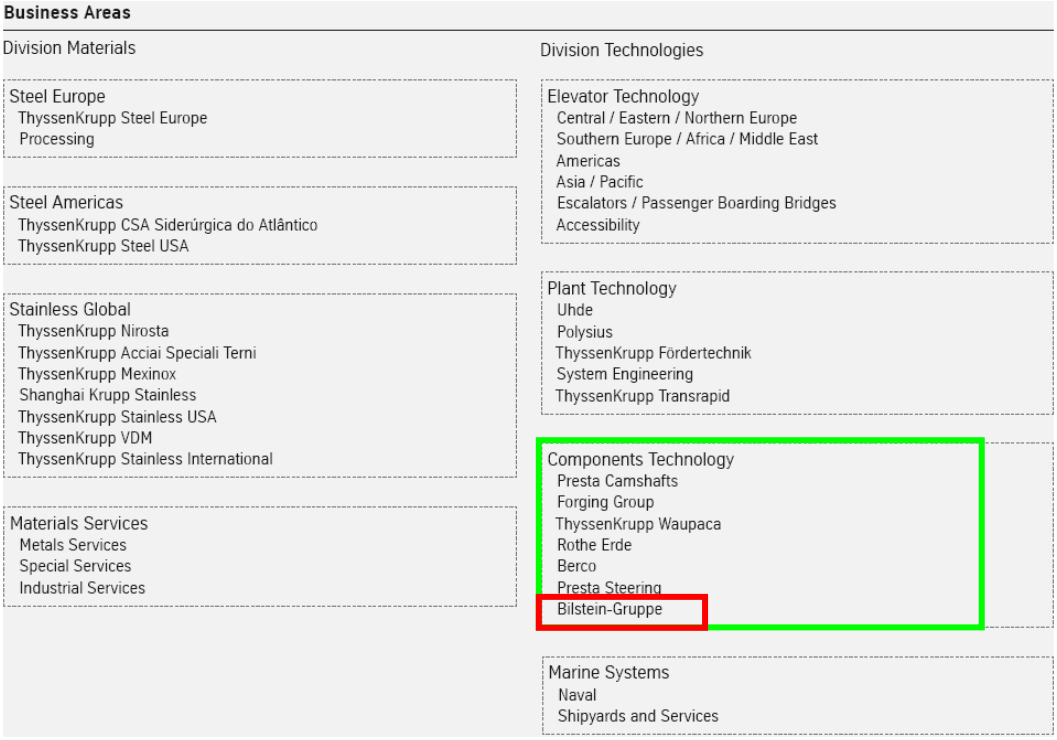


Figure 4.2 *ThyssenKrupp business areas ("Group - ThyssenKrupp AG," 2009).*

4.1.1 Environmental Care from ThyssenKrupp AG.

According to the TK-AG published letter, the location of any plant managed along free-market lines must be determined on the basis of the following principles within the context of Sustainable Development (Schulz, n.d.):

- Preservation and development of the plant's technological and economic performance
- Responsible conduct towards employees, neighbouring areas, shareholders and generations to come, and
- Implementation of a forward-looking policy of preventive environmental protection

The following statements are being extracted and resumed from the official documents available to the public referring to what the company's head managers promote as ThyssenKrupp Environmental guidelines that the *Bilstein Group* follows (Schulz, n.d.):

- Environmental protection is a top priority in the corporate policy; it acknowledges environmentally orientated management as an essential aim, considering environmental protection and economic efficiency as mutually dependent; then, by ensuring economic efficiency, ecological success can also be ensured.
- Nature interference is kept to an absolute minimum.
- Use of environmentally compatible production facilities and methods in plant, machinery, and in all other activities pursuing: lowest possible energy and raw materials consumption,

minimization of environmentally harmful effects, avoid wherever possible residuals and waste generation, or - if unavoidable - recycled o safely disposed of.

- TK-AG ensure from the conceptualization and design of its products, that they will generate no undue impact on the environment, be all economical as possible in terms of energy consumption and be optimally suitable for recycling or safe disposal.
- TK-AG cooperates with its customers and suppliers, seeking solutions towards optimizing environmental protection.
- TK-AG promotes ideas and research technologies for improving environment protection, that seek: keeping air and water cleaner, protecting soil, further reducing consumption of raw materials and using renewable resources.
- TK-AG takes part in joint initiatives, working closely with industrial associations, environmental protection bodies and state institutions.
- TK-AG seeks to engage in open dialogue on environmental issues with the general public and the authorities, seeing it as its duty to provide fast and comprehensible information to an environmentally conscious public.
- Environmental responsibility involves all TK-AG organization levels. Therefore, TK-AG provides in-line training in each respective field of work.

Nevertheless, there must be noticed that these statements are set by TK-AG as a corporation. Both plants studied in this research may have adapted their environmental policies to fit their capacities, production activities, workers extension, or other factors that may have been considered into the development and implementation of their respective Environmental Management System (EMS).

4.1.2 Bilstein Group Study Cases.

Formally named ThyssenKrupp Bilstein Suspension GmbH, this part of TK-AG was formed in 2005 and operates under the umbrella of the ThyssenKrupp Technologies Group, specializing in automotive chassis technology for damping and suspension. In this group are included the two plants of interest on this study research:

- *TK-Hagen*: ThyssenKrupp Bilstein Suspension GmbH, in Hagen-Hohenlimburg, Germany
- *TK-SLP*: ThyssenKrupp Bilstein SASA, S.A. de C.V., in San Luis Potosí, San Luis Potosí, Mexico

Products range of this firm encompasses standard products as steel dampers, full stabilizers, 1-tube and 2-tube shock absorbers, air suspension systems, tubular stabilizers and part-stabilizers, and adjustable shock absorbers, among others on research. In this study there are been considered two production lines: stabilizers (only in TK-SLP) and springs (in both TK-Hagen and TK-SLP).

Then, specifically referring to both plants of interest in this study research in Germany and Mexico, the production process starts from the metal pieces forming using heated steel bars to the final coated-protected piece which is to be pack and deliver to the clients.

Therefore, each metallic piece goes through different mechanical and chemical processes performed in order to obtain the final products with specified quality. Nevertheless, this study takes into account only three of them which are directly related with the use of hazardous substances and their generation of hazardous waste.

4.2 PROCESSES INVOLVING HAZARDOUS SUBSTANCES.

In the following sections the three processes are being described, as well as the differences and similitude among them. Consequently, it is important to remark that even final products are mainly the same, differences between plants organization, processes and substances management are considerably enough to result on different EMSs.

This section describes the processes of Pre-Treatment, Coating and Wastewater treatment, which were the focus of this study due to the use of HS in them. The information presented was provided by both companies' managers and verified on during the plants visits held as part of the fieldwork research of this study. In the case of TK-SLP, visits were carried out in July 2009; on the other hand, in the case of TK-Hagen were done in December 2009.

Differences between processes are described in this section; however, substances and other specifications are explained in the particular description of each plant.

4.2.1 Pre-Treatment. Phosphatise, Activation and Passivation.

In this stage, the main objective is to chemically modify the surface of the piece in order to make a phosphate layer on the surface that would serve as protection against metal corrosion.

At this point there is no difference between both lines of production process, referring springs pieces or stabilizer bars. However, even most substances have the same function in the process, many of them differ from plant to plant on their chemical constitution, due to chemicals regulations, price, market availability, among others reasons.

Until this stage, the piece has been formed and passed through other process being the last one an Abrasive blasting mechanical treatment that physically prepared the surface for the effectiveness of this chemical treatment. Figure 4.1 shows a general diagram that describes the

different steps and treatments that are involved in this process. The steps can be described as follow:

1. ***Degreasing:***[5] Process that uses a solvent (or cleaner) to remove fats and organic residuals from the metallic piece before the activation process.

2. ***Activation:*** The metallic piece is sprayed with a lightly alkaline solution of titanium salts that reacts with the surface of the metallic piece.

3. ***Phosphatise:*** After surface activation, the metal piece goes through sprayed Nickel and Zinc phosphates solution that would deposit the phosphate layer on the metal surface. This effectiveness of the process is enhanced with the use of a sodium nitrite solution that works as catalyst.

4. ***Washing:*** Pieces are washed with fresh tap water to remove excess of phosphates.

5. ***Passivation:*** After washing, pieces are sprayed with a fluorzirconic acid solution that would remove small particles of iron (or other metals which were not removed through washing) to prevent their further corrosion. A neutralizer solution of ammonium bicarbonate is also used to as pH controller.

6. ***Washing DI:*** The last washing before coating using deionised water in order to remove as possible impurities that may interfere with the coating process.

7. ***Blowing zone and drying*** steps have purpose of removing water residuals that would affect quality on the coating process.

[5] *This step is only done in TK-Hagen.*

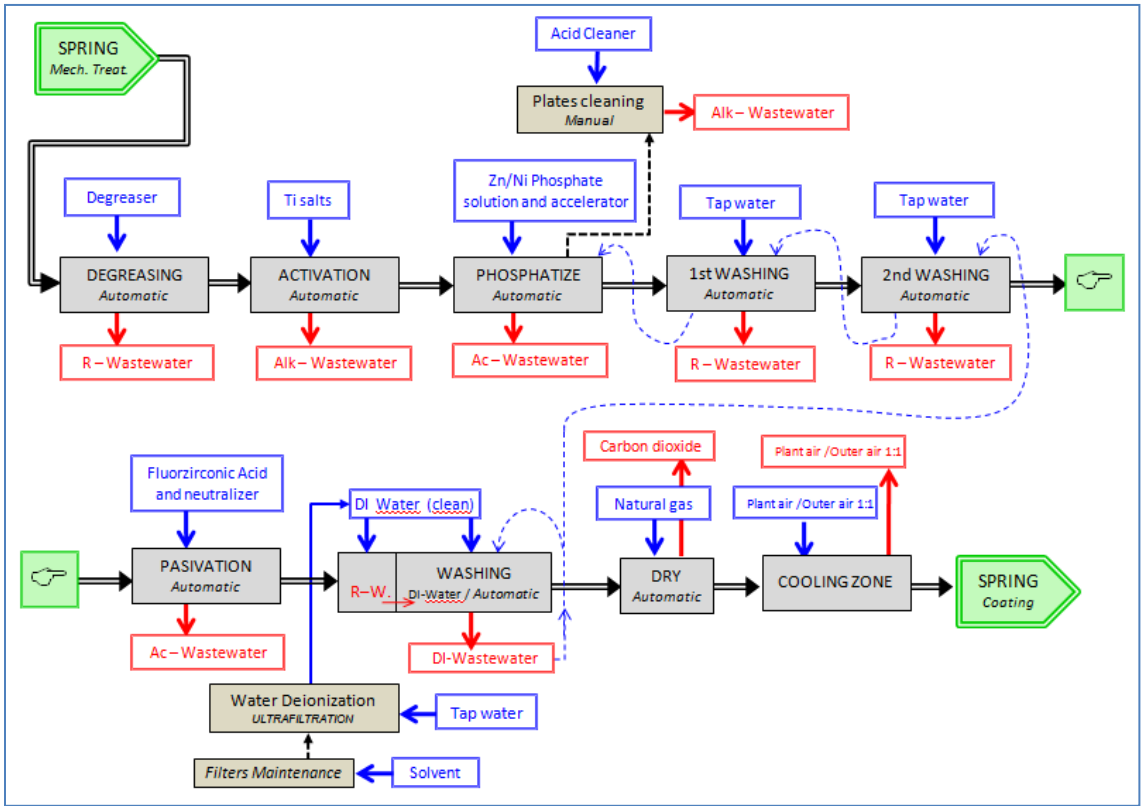


Figure 4.1 *Pre-treatment general diagram for TK-Hagen.*

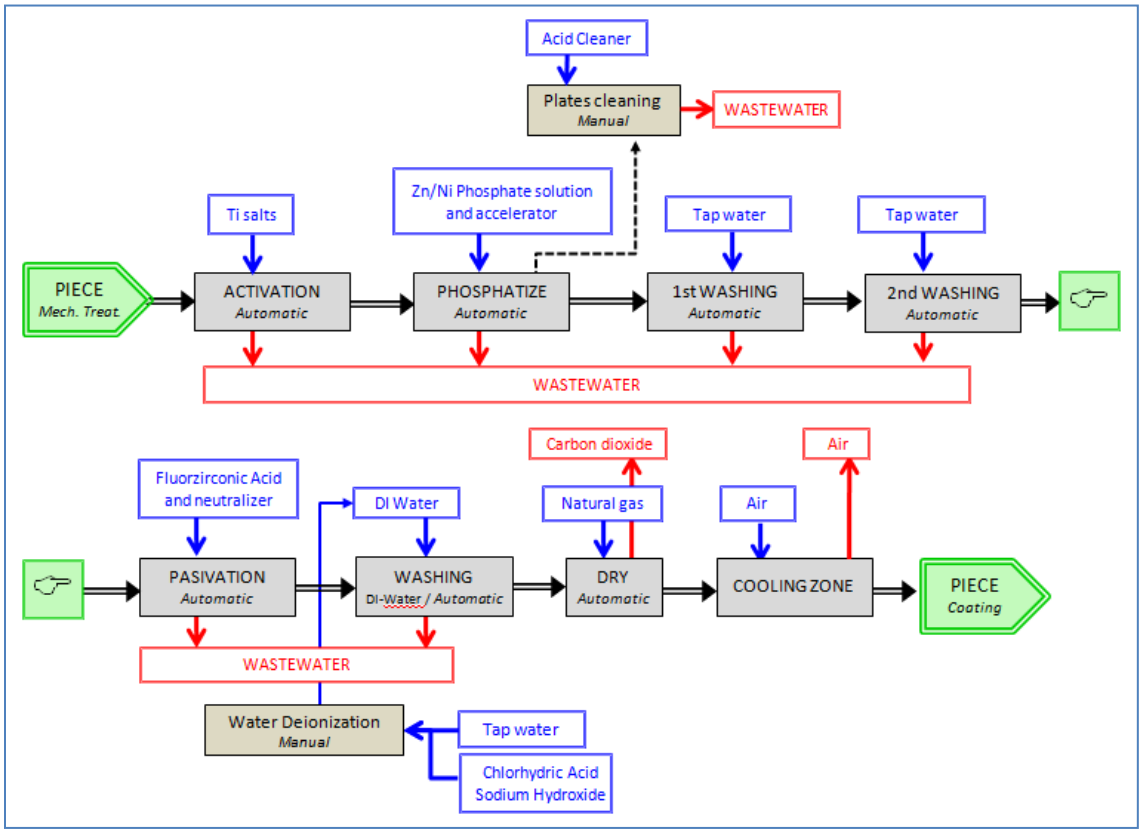


Figure 4.2 *Pre-treatment general diagram for TK-SLP.*

Alternative processes related with this basic line have also to be mentioned in order to have a more descriptive understanding of the substances that these processes involve:

- ***Plates cleaning:*** Referring to the washing of equipment (plates) to remove deposed residuals from the phosphatise process. In this step variants of hydrochloric acid are used.

- ***Deionisation:*** This refers to the process that treats tap water in order to obtain deionised quality water suitable for specific washing steps in which residual salts may interfere in the following process. The use of chemical substances depends on the technology available. Filters only require cleaning once per year with acid variants; chemical deionisation is done with calcium hydroxide and sodium hydroxide.

Wastewater in TK-SLP is recollected from all involved processes and directed to the small Wastewater Treatment Plant (WWTP) specialized for this processes. On the other Hand in the plant of TK-Hagen, wastewater from processes are recollected in different tanks and then partially mixed to be treated in also a small WWTP *(this process is detailed in section 4.2.3)*.

Moreover, in TK-Hagen deionised washing wastewater (DI-Wastewater) is mixed with tap water and used on the previous washing stages, in order to avoid extra water consumption; in TK-SLP this DI-Wastewater goes directly to the special wastewater treatment plant.

4.2.2 Coating.

After the Pre-treatment, the metallic pieces have been covered with a phosphate layer against corrosion. However, without any more protection this layer would fall within time and leave the piece exposed to air and humidity, factors of corrosion.

For this reason a coating treatment is necessary, in which as general description a layer of protective paint is deposited on the surface of the piece, protecting the phosphate layer and therefore improving corrosion protection.

A general description of the process can be also made in order to have a general explanation of the stages. However, there are slightly differences among production lines stages and chemical substances used. For this reason, flow charts are show separately for each production line and plant (Figures 4.3, 4.4 and 4.5); in the same way, the main coating paints differ from plant to plant.

1. ***Coating:*** In this stage of the process potent sprinklers shoot high-pressure spray of pulverized polymeric paint to the metallic pieces. The paint fixes to the surface of the piece mainly through electrostatic forces. Nevertheless, depending on the type of piece and the client's requested coating would be the way the line is formed and the substances to be used:

a. ***Single and Double Layer Coating:*** While in the first type the metallic piece is sprayed only once with the appropriate coating substances and then enters to polymerization, in the second one the metallic piece is sprayed twice to enhance corrosion protection with different coating substances each time. Subsequently, pieces must pass also twice through heated ovens for polymerization. In both cases, the non-fixed powder paint can be collected, mixed with non-used powder paint and sprayed to the metallic piece, this with the purpose of optimizing material resources and minimizing waste generation. *(see Powder paint collection)*

b. ***Tips Coating (Stabilizers):*** A coating exception procedure in case of stabilizers that uses liquid enamel. Since pieces' tips are required to remain with minor coating thickness than the overall obtained on the metallic piece after the coating process, the coating layer from these parts of the stabilizer is blowed off before the piece enters to the polymerization oven; then tips are cooled and submerged in Acrylic Black enamel. Finally, they are left to dry at room temperature.

2. ***Polymerization:*** Refers to the slow passing of the metallic pieces inside an high-temperature heated oven (~90-150°C) in order to induce the already fixed coating layer to polymerize, meaning with this the forming of a thick plastic layer that would repel water contact with the metallic interior, and therefore avoid corrosion. This process is done as many times as the coating with polymeric paint. Heating ovens use on both cases Natural gas as combustible.

3. ***Cooling:*** Since after polymerization the metallic pieces remain at high temperature, inducing rapid temperature diminution is required in order to have a uniform polymerization on the surface of the piece, avoid bubbles or other possible imperfections on the products quality.
The cooling methods applied differ from product lines and industrial plants, although both are considered to be effective. They are: (a) Immersion of the pieces in a fresh water (tap water) cooling bath; (b) Sprinkling of clean DI-Water for stabilizers, in order to avoid impurities that interfere on the following Tip Coating procedure. After this, pieces are either dried by air exposition or manually wipe.

4. ***Identification:*** Final products are marked with small coloured line (or lines) in order to differentiate between Client's and requested orders. Such marks are done manually using small brushes and acrylic paint; mistakes are corrected removing paint with solvents.

There are parallel procedures to the coating process that interfere directly or indirectly with the chemical substances management. For this reason, it is important to describe them even though they have no effect on the finals products quality.

- ***Powder paint collection***: In order to optimize materials use, both plants have implemented collection systems to recover the non-fixed powder paint and reuse it in the process. As shown on process flow diagrams, the used systems with this purpose are two: ***(a) Cyclones***

used in TK-SLP, mechanically recover fine dust of this powder paint using air suction and sieve systems; and the ***(b) Manual collection*** method used in both plants, in which workers using tools like dustpans recover accumulated dust inside cabins where the spraying is done. Finally, dust has to be mechanically sieved.

The recovered paint is not directly sprayed for a second time, but mixed with non-used powder paint and then sprayed.

Non-reusable paint dust (contaminated with soil dust and other particles) is collected and disposed as Non-Dangerous Waste in TK-SLP; on the other hand, according to the information provided in TK-Hagen, the effectiveness of the recovering procedure in this plant do not lead to the generation of paint's dust waste, therefore there was no report on dust recovering or management of this kind of waste from the plant's managers.

- ***Equipment Maintenance (E.M.):*** All equipment needs to be revised and cleaned in order to keep its functionality. Depending on the equipment that has been maintained is the type of generated waste. Therefore, maintenance from the inside of coating cabins leads to Reusable powder paint, but from the outside is classified as Non-reusable dust. On the other hand, production line maintenance like hooks burning, or even towels with oil stains or solvent residuals stains, are classified as Industrial garbage in TK-SLP, and as Toxic Waste in TK-Hagen.

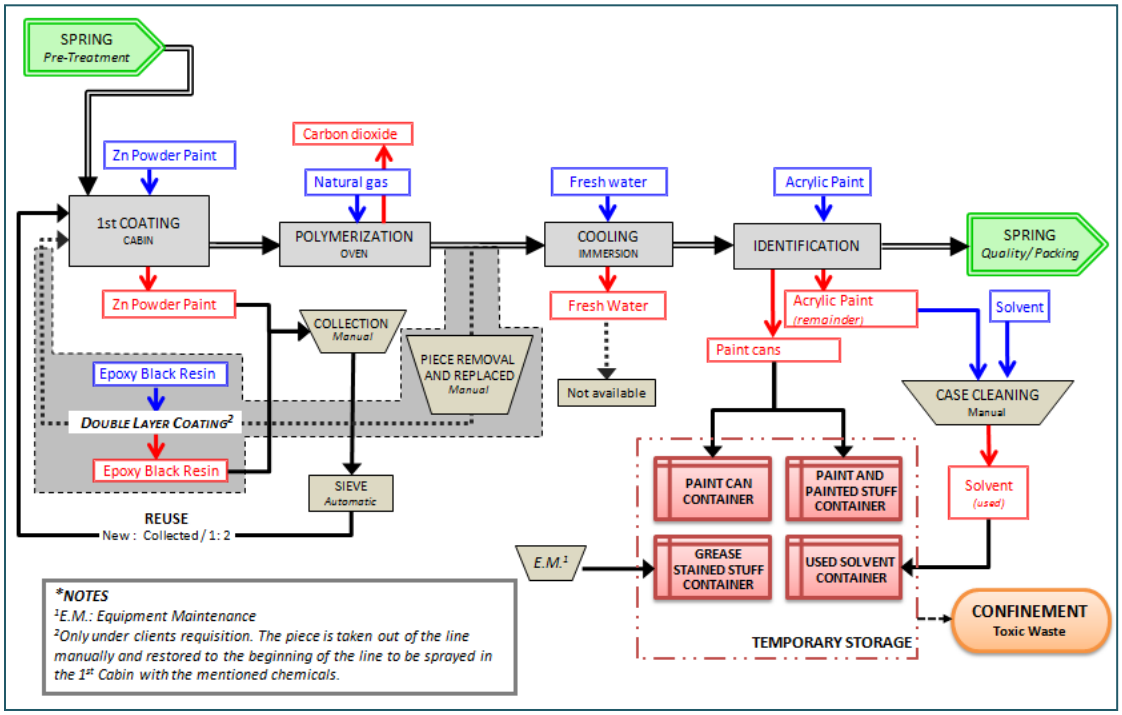


Figure 4.3 *Coil springs production line. Coating process diagram for TK-Hagen.*

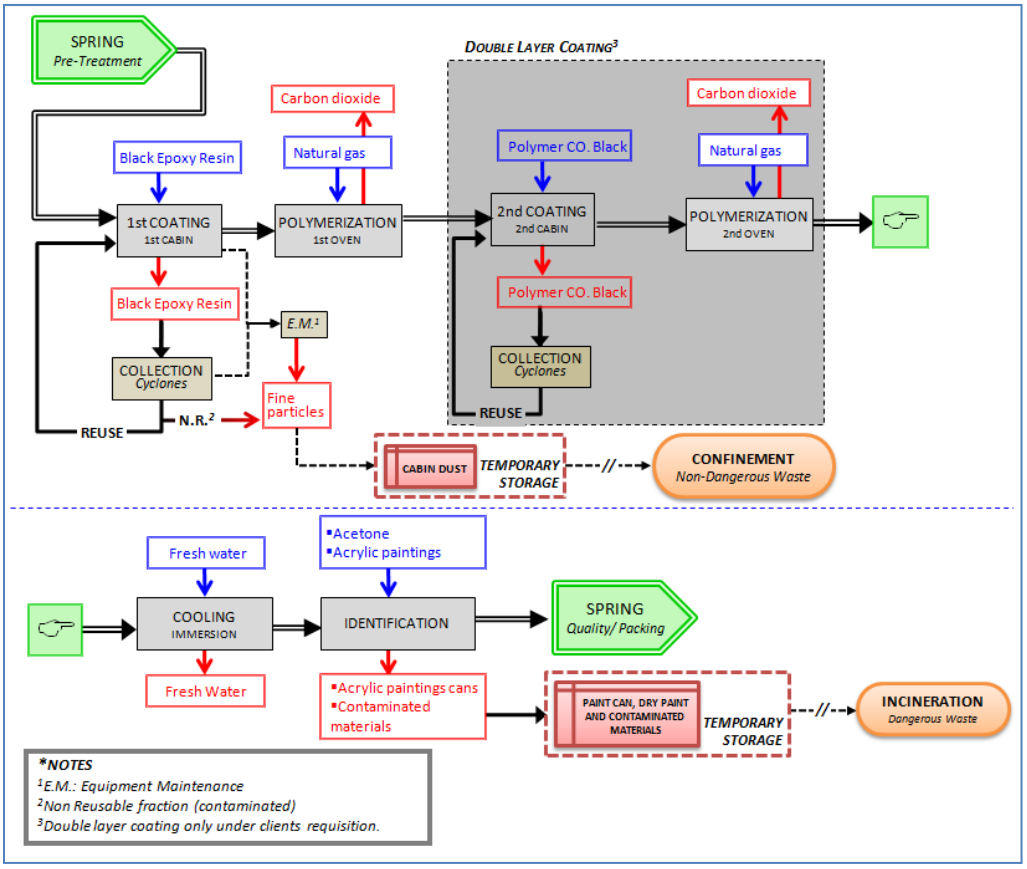


Figure 4.4 *Coil springs production line. Coating process diagram for TK-SLP.*

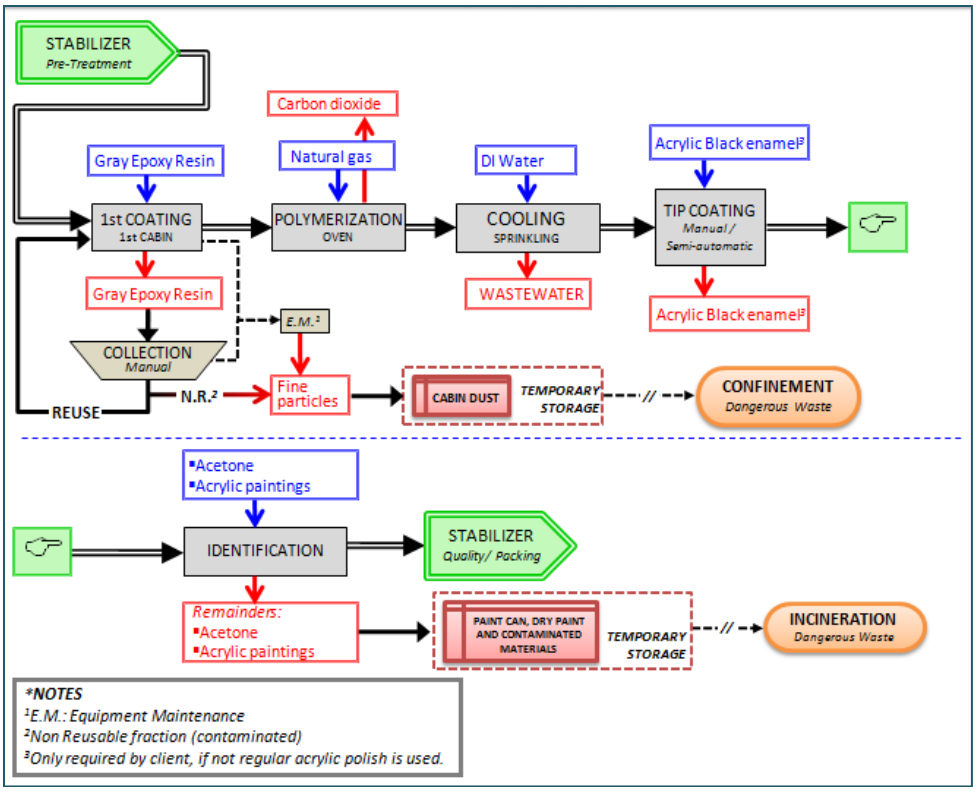


Figure 4.5 *Stabilizers production line. Coating process diagram for TK-SLP.*

4.2.3 Wastewater Treatment from Pre-treatment process.

Wastewater Treatment is of great importance from the Hazardous Substances Management perspective. The beginning of the process is by the collection of the wastewater (WW) generated by each of the different stages of the Pre-Treatment process, collection methods differ from plant to plant as well as treatment procedures. Processes diagrams on the function of the Wastewater Treatment Plants for WW generated in the Pre-Treatment process in TK-Hagen and TK-SLP are shown on Figures 4.6 and 4.7 respectively. Nevertheless, general concepts on both plants can be described as follows:

1. ***Collection:*** Refers to the wastewater collection in one or different tanks from the different stages of the Pre-treatment process (e.g. Activation, Phosphatise, Passivation, among others).

2. ***Neutralization:*** Stage of the process in which chemical substances are used to modify the pH of the collected WW regulating its value to 6 to 10, in order to facilitate later sedimentation and flocculation activity. The substances that are used in this stage can be chemical acids or alkalis. The tank must be continuously stirred in order to obtain a homogeneous condition.

3. ***Flocculation:*** This stage involves the use of chemical substances *(flocculants)* with the chemical capacity of forming aggregates from suspended solid particles. Such substances can be of different nature, either metallic salts or cationic or anionic resins (e.g. $FeCl_3$, ionic polyelectrolytes), and their selection would mainly depend on the type of the process and desired quality on the treated wastewater. Slow stirring and/or mixtures different flocculants can be used in order to improve the flocculation process.

4. ***Sedimentation:*** Wastewater from flocculation is conducted to a tank where the formed aggregates are deposited in the bottom due to density and gravitation. This process can be slow and tank must not include stirring or any other mixture device that disturb particles sedimentation. Treated Wastewater is extracted from the top of the tank, while deposits form sludge from the bottom. Sludge is taken out by opening the bottom tank valves, collected and classified as Dangerous Waste. It can be either directly send to temporal storage (TK-Hagen) or compressed using a special press and filters to remove to minimum water content and then stored (TK-SLP).

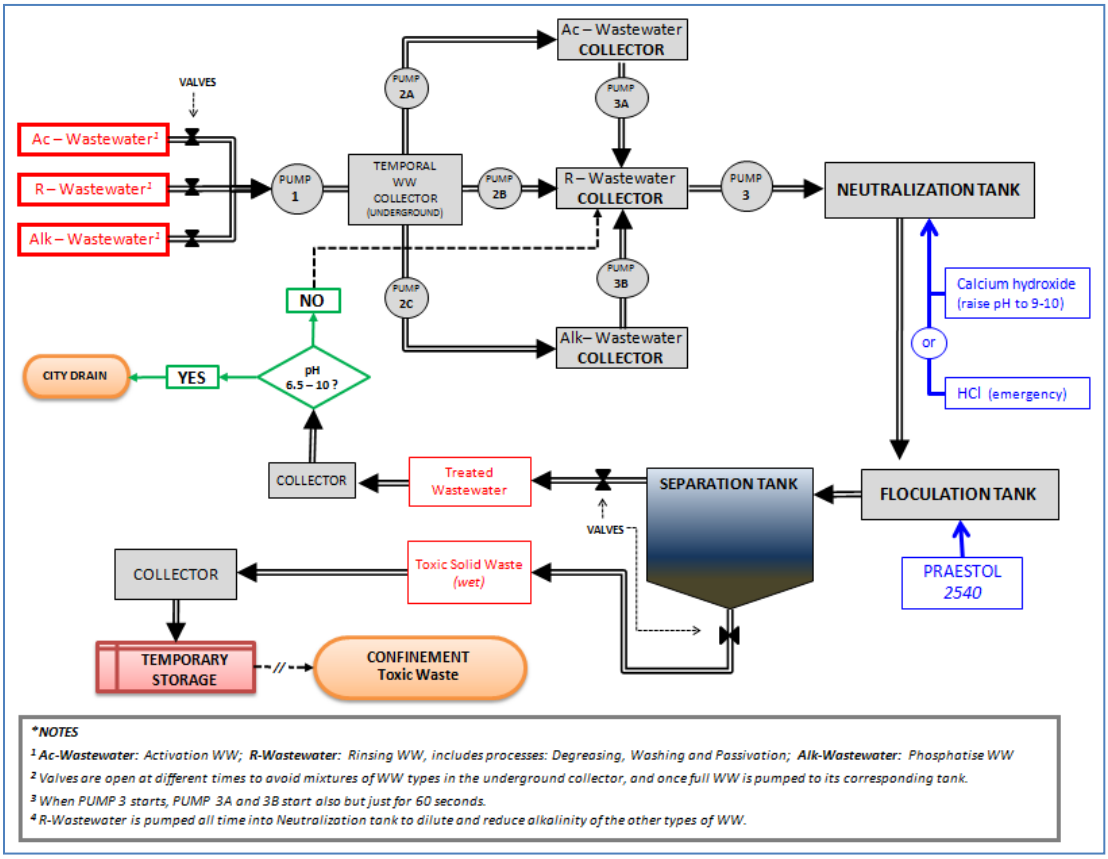


Figure 4.6 *Wastewater Treatment Plant. Process diagram for TK-Hagen.*

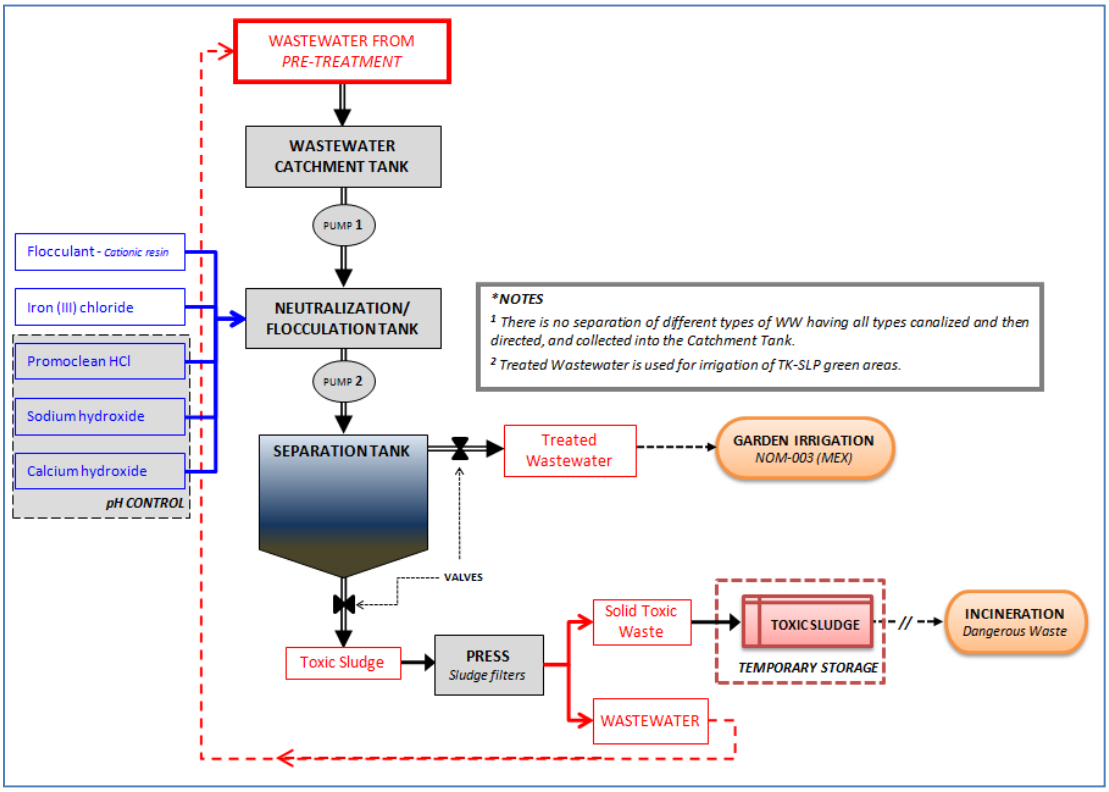


Figure 4.7 *Wastewater Treatment Plant. Process diagram for TK-SLP.*

4.3 INDUSTRIAL PLANT IN HAGEN-HOHENLIMBURG, GERMANY – TK-HAGEN.

4.3.1 Plant overview.

Name: ThyssenKrupp Bilstein Suspension GmbH

Plant Address: Oeger Strasse No. 85, 58119 Hagen-Hohenlimburg, Germany

The name *ThyssenKrupp Bilstein Suspension GmbH* includes all plants of the Bilstein Group that are distributed in Germany in the urban districts of Mandern, Olpe, Ennepetal, Werdohl and Hagen. The plant of interest is the one located in the in the city of Hagen-Hohenlimburg, Germany in the urban district of Oege. Therefore it is frequently identified as Plant Oege *(Werk Oege).*

The city of Hagen is part of a historically known industrial zone of the country, currently known as the Ruhr area *(Ruhrgebiet)*. The plant has a history over a hundred years on metal processing, being one of the first's plants that would integrate today's *ThyssenKrupp Bilstein Suspension* group. For this reason, the plant is surrounded by other industrial plants; some of them also part of *ThyssenKrupp AG.* However, activities held on this company have to consider the communities established in the surroundings, among private houses, small commercial locals and even a primary school, all at no more than 10 minutes walking from the plant.

Figure 4.8 *Front entrance of TK-Hagen industrial plant (Photo: ISGUS GmbH, 2008).*

The plant includes only one production line for automotive ***springs***. For this reason, its extension is relatively small in comparison with TK-SLP. Nevertheless, production is considerable enough as well as the use of hazardous chemical substances, to be of interest on this master study.

The description of TK-Hagen EMS management, regarding the hazardous substances management in the processes of: Pre-Treatment, Coating and Wastewater Treatment, has been done from first hand information obtained from interviews with personnel of *ThyssenKrupp Bilstein Suspension GmbH* in the Hagen-Hohenlimburg plant, as well as personal observation on visits in the plant. The

gathering of this information was part of the first fieldwork research done between December 9th and 11th, 2009.

4.3.2 Environmental quality plant certification.

As many plants that integrate the *ThyssenKrupp Bilstein Suspension* group, TK-Hagen has a certified EMS complying with the DIN EN ISO 14001:2005, which applies to a management system with the scope on *"Product design and development, manufacturing of coil springs for the automotive industry"* (TÜV NORD CERT GmbH, 2009). The certification was obtained on November 11th, 2009 and is valid until October 31st, 2012.

The documented Management Handbook (TKT-BIS) was developed under the DIN EN ISO 14001:2005 and BS OHSAS 18001:2007 parameters, integrating main concepts on Industrial Safety, Health and Environmental protection. This documented and certified EMS is available only for internal access on the company's intranet.

The TKT-BIS is a revised and the established Management System audited through internal and external audits, scheduled by an Audit Plan per year that covers the five plants of *ThyssenKrupp Bilstein Suspension GmbH* located in North Rhine-Westphalia, Germany.

Additionally, the EMS is audited each three years from an authorized TÜV auditor, in order to renovate the ISO 14001 certification.

According to the Environmental Management Representative in TK-Hagen, this handbook is available for other plants in the *ThyssenKrupp Bilstein Suspension* group around the world. Therefore, all plants must have the same Environmental Policy and Commitment.

Environmental Policy (ThyssenKrupp Bilstein Suspension GmbH, 2009)

Management Policy

The company ThyssenKrupp Bilstein Suspension GmbH is aware of its responsibility of its economical actions, for assuring in Working places, health and safety of Employees and the Environment protection.

Operational safety and Environmental protection are also important elements of corporate management as the goal of production and distribution high quality products at low cost.

The management is committed to compliance with all legal and other requirements.

The impact of our activities on the local surrounding region would be monitored and assessed. Occupational safety aspects and the environmental impact of any new activity, and each new procedure will be assessed in advance. Processes and procedures will be introduced under consideration of safety and health of employees and on the basis of environmentally friendly technologies, taking into account the economic possibilities.

It will be taken the necessary measures to limit to a minimum the impact on employees and the environment. The conservation of resources such as raw materials, energy and water is a central aspect. It introduces procedures to ensure, in the case of operational disruption to limit the impact to a minimum and ensure prompt notification to the competent authorities and communities.

ThyssenKrupp Bilstein Suspension GmbH establishes to be always open to dialogue with the public. Our customers are consulted on aspects relating to the appropriate handling, use and recycling opportunities of our products. We take precautions to ensure that our partner companies working by contracts work undertaking the same standards as the ThyssenKrupp Bilstein Suspension GmbH.

ThyssenKrupp Bilstein Suspension GmbH has introduced a management system to implement and ensure these goals. The management system is consistently applied, reviewed and enhanced in order to adapt it to the changing circumstances. The framework for the continuously improvement process on the areas of Occupational Safety, Environmental protection and Fire prevention hold on national and internationally accepted standards.

For this continuous improvement process the experience and skills of staff must be used. Therefore, ThyssenKrupp Bilstein Suspension GmbH supports initiatives and suggestions of employees, which may contribute to achieve the company's goals.

The policy of the company is determined by the company's administration, and it is regularly controlled on time intervals on the basis of internal and external audits and adjusted as necessary. It is made public among all employees of the company and all persons working on behalf of the TKT-BIS, in an appropriate manner.

The policy is concise in the following guiding principles expressed.

Management System principles (ThyssenKrupp Bilstein Suspension GmbH, 2009)

For our employees, the following binding guidelines:

- *Safety, health, environmental protection and fire prevention are important parts of our management.*
- *We deliver to our customers: reliable, high quality and environmentally friendly products.*
- *There shall no emanate any danger from our plants to the people and the environment, the Safety and health of our employees is a priority.*
- *Environment is stressed as little as possible from our manufacturing process.*
- *We train our staff continuously, while we promote awareness of safety, health, fire, and environmental issues.*
- *We handle natural resources as carefully as possible.*
- *We look after an optimal use of energy in all plants and areas.*
- *We meet as minimum standards with laws, regulations and regulatory requirements.*
- *We work together with authorities, insurance companies, technical and scientific institutions to implement the Safety, Health, Environmental and Fire prevention requirements.*
- *We use organizational and technical means to monitor compliance with this guidelines and performance in the area of Environmental protection with the purpose of growing a continuous improvement process.*

4.3.3 Chemical Substances involved in the industrial process to study.

4.3.3.1 Inputs and outputs substances. Hazard levels to consider.

Along the different processes that are held in TK-Hagen, several chemical substances are being used and, according to their reported properties in the Safety Data Sheets, many of them can be considered as Hazardous Substances. However, due to confidentiality and information restrictions, it is not possible to report substances detailed composition and sometimes even commercial names in the published documents of this research.

Table 4.1 indicates a list of the chemical substances that are involved in the processes of interest for this study (i.e., Pre-Treatment, Coating and Wastewater treatment); the ones considered as hazard substances, according to the quantities of use are shadowed. In this list is noticed the different hazard levels of each substance, which corresponds to the GHS classification *(see Chapter 2).* All the shadowed substances are daily used as explained in the previous processes' descriptions; thus, workers and environment are daily exposed to considerable quantities and to the risk these substances represent.

Some substances from which information is not available, due to information restriction, are equivalent between processes held on TK-Hagen and TK-SLP; therefore, the composition of these substances have to be similar, in order to maintain product's quality and subsequently, it is valid to suppose a parallel hazard level and it is expected that generated waste to be also similar.

In conclusion, TK-Hagen includes around 14 different chemical substances in the processes of Pre-treatment, Coating and Wastewater Treatment, from which 12 can be identified to be potentially hazardous substances either for human or environment. This represents around 85% of the substances involved in these processes.

Table 4.3 *Input Chemical Substances used in studied processes in TK-Hagen.*

PROCESS	SUBSTANCE	MAIN COMPONENTS	MAIN HAZARD	OTHER POTENTIAL HAZARDS
Pre-Treatment	*Ridoline 1205*	Alkaline salts and non-ionic surfactants (fluortitanates and tetraborates)	Toxic	Irritant, teratogenic and environmental danger
	Fixodine C9114	Sodium and Calcium alkaline salts (phosphates, nitrates, fluortitanate)	Irritant	Corrosive, oxidant and toxic
	Granodine SP2500	Zinc and nickel alkaline salts and acids (phosphates, nitrates)	Toxic and Environmental Danger	Harmful, corrosive, oxidant and irritant
	Grano Toner 130	Sodium nitrite solution	Oxidizing Toxic Environmental Dangerous	Fire danger, toxic for human and aquatic life
	Deoxylyte 54 NC A	Fluorzirconium acids and salts	Corrosive	Toxic
	Deoxylyte Toner	Inorganic salts (sodium carbonate)	Irritant	Toxic for aquatic life
	Hypersperse MDC150 [1]	N.A.	No particular hazard	Slightly health danger
	Phos-Clean	Organic and inorganic acids and surfactants	Corrosive	Very toxic and environmental danger
Coating	*Zn-Powder Primer* [2]	N.A.	N.A.	N.A.
	Epoxy Black [3]	N.A.	N.A.	N.A.
	Thinner (solvent)	Organic solvent	Harmful and Environmental Danger	Irritant
Wastewater Treatment	*Calcium hydroxide*	Inorganic alkali	Irritant	Intense or continued but not chronic exposure could cause possible residual injury
	Praestol 2540	Polyelectrolyte acrylamide and sodium acrylate	No particular hazard	Slightly hazardous to water
	Hydrochloric acid	Inorganic acid	Corrosive	Short exposure could cause moderate injury

**Hazardous substances are the ones marked with gray shadowed rows.*
[1] Not considered as highly hazard due to use on small quantities and once per year frequency.
[2] Product name not available; Equivalent product to Corvel Zinc Gray used in TK-SLP, therefore supposed similar Hazard
[3] Product name not available; Equivalent product to Corvel Black used in TK-SLP, therefore supposed similar Hazard

4.3.3.2 Hazardous Substances Management I. Personnel safety measures.

Workers in TK-Hagen had to pass through a previous training program, which prepares personnel to know how to use the corresponding machinery. During these programs, personnel are warned about the risk they are being exposed to, how they should manage an emergency situation and who should they notify in these cases. The existence of these programs was mentioned during interviews with managers in the area; however, there were not given more specific details about these programs.

On the other hand, inside the plant, signs and advertisements indicate all personnel the obligatory use of personal protection equipment:

- Safety helmet
- Safety boots
- Safety glasses
- Disposable face masks
- Disposable foam earplugs
- Boiler suit (protective complete suit)

However, it was noticed that some workers did not wear some of the required equipment, like masks or glasses, at the moment of inspection, which denotes a necessity of mayor supervision on this issue.

Moreover, as an additional note, there was no inspection on the use of this protective gear at the moment of the plant inspection, except for the earplugs; this comment contributes to the previous note on the need of mayor supervision on workers personal safety equipment.

4.3.3.3 Hazardous Substances Management II. Environmental management.

SUPPLIER'S RESPONSIBILITY.

This section refers to the TK-Hagen's procedures on the acquisition of chemical substances that would be used in the processes of interest.

Though suppliers' names are not to be mentioned in this document, it can be stated that, according to the information provided from the plant's Environmental Management Representative, all services and materials suppliers are required to count with a certification either on management quality or environmental management.

Therefore, it was verified that two of the identified TK-Hagen's chemicals suppliers for the input substances in the process of interest count with management certification (i.e., ISO 9001), two more presented additional environmental and occupational health and safety management

certification (i.e., ISO 14001 and OHSAS 18001) and one of these has been recognized with a Responsible Care® certification (i.e., RC 14001).

Then, in order to maintain a complete registry in the chemical products used in the plant, TK-Hagen demands the provision of the corresponding Safety Data Sheets of all chemical products that are acquired.

STORAGE CONDITIONS AND SAFETY MEASURES.

Supplementary visits to the chemical materials storage site of the plant could not been carried out due time difficulties presented during the fieldwork research. Therefore, since there was no personal verification of the site, it cannot be given specific information about its conditions and management.

However, it must be stated that according to the information provided in TK-Hagen, the storage conditions are revised by the corresponding department and comply with legal requirements that involve the occupational health and safety. The safety and risk planning , as well as the document control is informed to be in compliance with the corresponding German regulations for HS (Regulation for the protection from hazardous substances; *GefStoffV, Appendix III*), as well as their inclusion in the overall management of the plant under the standards ISO 14001 and OHSAS 18001.

USE AND ACCIDENT MEASURES.

Chemical substances use during the different processes in TK-Hagen can be extracted from the processes described in section 4.2 and the analysis of the corresponding figures to TK-Hagen production and lines (Figures 4.2 and 4.3).

Then, in order to complement the information in these diagrams is noted that:

- In the Degreasing, Activation, Phosphatise and Passivation steps, workers add manually measured quantities of the corresponding chemical substances to the collectors, using then proper latex gloves; these collectors contain deionized water that dilute the substance and is verified that concentrations are kept.
- In the Coating processes, the substances management is mainly manual. Workers use small shovels to deposit powder paint into the machinery that is connected to the automatic sprinklers.
- Non-fixed substance, is recollected, sieved and reused, in order to avoid materials looses or the increase on waste generation. This is mentioned on section 4.2.2: non-fixed paint is manually collected using dustpans, automatically sieved and mixed with non-used paint.
- Moreover, the coating tunnel is located inside coating cabins, which works at the same time as physical barriers against dust spread in the plant's atmosphere.
- All machinery that involves the use of chemical substances has its corresponding risk awareness signs (using the NFPA diamond).

For TK-Hagen study case, specific information about accident measures, involving spilling, leakages and substances escapes, could not be gathered due to time difficulties presented. However, it must be said that, according to the information provided by the plant's managers, such control and planning is in compliance with the corresponding German regulations (*GefStoffV, §8 to §12).*

Additionally, those measures are informed to be included in the company's Management Handbook as part of the compliance with Occupational Health and Safety requirements from OHSAS 18001.

It was also mentioned that procedures, providing descriptive indications to have in these processes, are reported in the TKT-BIS. However, there was not access provided to the full content of such document.

Then, referring to the environmental impact specifically on the processes carried out, it can be mentioned that:

- The processes use water as a dilution base for most of the steps that involve chemical substances. Therefore, the use of such substances impact mainly on wastewater properties.
- Analyzing the process done in the Coating cabin, it can be said that the spread of fine particles is also of interest. However, there was not information available for it; moreover, this issue was not even marked as potential impact.
- Ovens and heaters work mainly with natural gas, from which main combustion products are CO_2, CO and NOx (Serrano & Sánchez, 2005). TK-Hagen manages environmental legal compliance of such products by the implementation of chimneys. This in order to obey green gases emission limits, established by Federal regulations on matter of air protection. However, the effectiveness of this procedure is not studied on this research, due to the limits on its extension.

WASTE COLLECTION AND TREATMENT (INSIDE THE PLANT).

From the processes of interest held in TK-Hagen, generated and collected waste are:

- *Wastewater*: collected from the different stages on the Pre-treatment process;
- *Contaminated materials*: empty paint cans, solvent and paint stained stuff, among others, collected from the identification of each piece (see Fig. 4.3).

The second type is considered final waste and is described in the next section. On the other hand, generated wastewater pass through a Wastewater Treatment (WWT, *see section 4.2.3*), and the effectiveness of such process in TK-Hagen plant is described in this section. Nevertheless, it is important to remark that this process covers only environmental impact from the Pre-treatment process.

WWT is essential to remove phosphates residuals and other inorganic substances that affect water's quality and make it unusable for other purposes. Then the quality of the treated

wastewater shall consider its following use. In case of TK-Hagen, treated wastewater is directed into city's drain and then it is treated under different processes.

However, the plant considers that the treatment is effective if some of the measured physicochemical parameters comply with the local and federal established limits. The parameters taken into account in order to verify efficiency on wastewater treatment are shown in Table 4.2.

In order verify regulations compliance, TK-Hagen counts with a small laboratory that makes quick test to manage a rough control of the quality of the process. Then they send once per month to a private laboratory, samples from the Neutralization tank and from an "End-control" sample point (before treated wastewater reaches canalization).

Then, each two years local authorities on Wastewater matter of the city of Hagen visit the plant to revise the compliance with local regulations. On the same way, Federal environmental authorities visit the plant each three to four years to revise compliance with federal established limits.

Table 4.2 *Physicochemical parameters measured in TK-Hagen WWT.*

PARAMETERS		CONTROL VALUES GUIDELINE
Metals	- Zinc (Zn) - Total Chromium (Cr) - Iron (Fe) - Chromium VI (Cr-VI) - Nickel (Ni) - Cadmium (Cd). - Lead (Pb)	Annex 40 - Regulation of requirements for the discharge of Wastewater into Waterbodies *(Abs. 40- Abwasserverordnung - AbwV).*
Inorganic compounds	Nitrites (NO_2^{-1})	Value established by local authorities
	Phosphates (PO_4^{-3})	No guideline
	Sulfates (SO_4^{-2})	
Other parameters	Chemical oxygen demand (COD)	
	Cation exchange capacity (CEC)	

It can be noticed that phosphates, one of the most important residuals regarding the type of process, is not controlled under an official guideline. On this matter, the reports on wastewater analysis of the company have demonstrated that the process remove about 65% of the phosphates concentration, comparing both samples results. Nevertheless, the resulted value is still considered as an elevated concentration, since it does not even comply with the established federal limit on *Annex 40, AbwV*.

However, what can be considered as a poor control on this parameter, relays on the fact that this parameter is not required to be controlled, since the established parameter found in *Annex 40, AbwV* is applicable only when wastewater is not combined before been discharged into waterbodies. In TK-Hagen' case, treated wastewater joins the drainage of the urban zone.

FINAL GENERATED WASTE INTERNAL MANAGEMENT.

The final waste generated from the processes of interest refers mainly to:

- Sludge generated on the WWTP (from Pre-Treatment process), and

- Contaminated materials from the identification final stage.

Both types of waste is considered and labelled as Hazardous Waste and it is managed following the steps established on the plant's EMS relating Waste Management.

Sludge from the WWT is collected in special containers, classified as toxic waste, temporally stored in the plant's waste warehouse and finally collected by special industrial waste collection services. However, since supplementary visits could not been carried out on these storage site, no more specific information about characteristics and storage conditions, neither of containers nor the temporal waste warehouse, could be gathered due to time limitations on the fieldwork visits. It is worth mentioning that, according to TK-Hagen's managers, the conditions of this place are verified and meet legal requirements on occupational safety in storage places for HS (*GefStoffV*, App. III, 1.5).

Contaminated materials are collected in a designated space inside the plant, where four types of temporal containers were identified: (1) Paint can container, (2) container for paint residuals and materials contaminated with paint residuals, (3) container for grease-stained stuff, and (4) used-solvent container. Though, they are different types of waste and later transferred to separate containers, they are all classified as hazardous waste and collected by special industrial waste collection services.

SPECIAL WASTE COLLECTION SERVICE AND FINAL DESTINY RESPONSIBILITY.

After waste is collected from TK-Hagen, it is classified as "special waste" *(Sonderabfälle)* and different companies (depending on the type of waste that is produced) have the responsibility of having an appropriate handling of it in compliance with the European Directive 91/689/EWG and the German Law to promote circular economy and ensure the environmentally compatible disposal of waste (*KrW-/AbfG*, §29 and §41).

Nevertheless, this is not the end of the plant's responsibility as waste generator. The company has the legal obligation of assuring that the generated waste is handled and disposed in a legally approved method. Therefore, TK-Hagen takes into account different precautions to select the collection service companies, in order to comply with their environmental principles.

TK-Hagen administration owns a list of companies (not included in EMS document) that provide the special waste collection service. Listed companies have been approved by previous evaluation that includes compliance with:

- ISO management certification
- Management system annual auditing program

Furthermore, TK-Hagen complies with regional official requirements on the document backup procedures relating special waste transportation and final elimination. These procedures provide the company documents for proving the consignment and final elimination of the special waste generated. Then, TK-Hagen also presents local authorities the corresponding documents

demonstrating such actions. Figure 4.9 illustrates the waste consignment notes reception and delivery, according to the different involved activities.

Nevertheless, there was no disclosure from TK-Hagen Environmental Department about the final confinement site or hazard minimization treatment on generated dangerous waste. Therefore, it can be noticed that even legal compliance is achieved, it cannot be discussed whether an environmental responsible care is been actually taken or not, relating to the hazard minimization on dangerous waste management.

Then, according to Figure 4.9, it can be noticed that generated waste is sent to final disposal, and according to the information provided during the interview with the with Environmental Management Representative of TK-Hagen, the company has among the company records, the corresponding Waste Consignment notes indicating the information about the transportation service and final waste location.

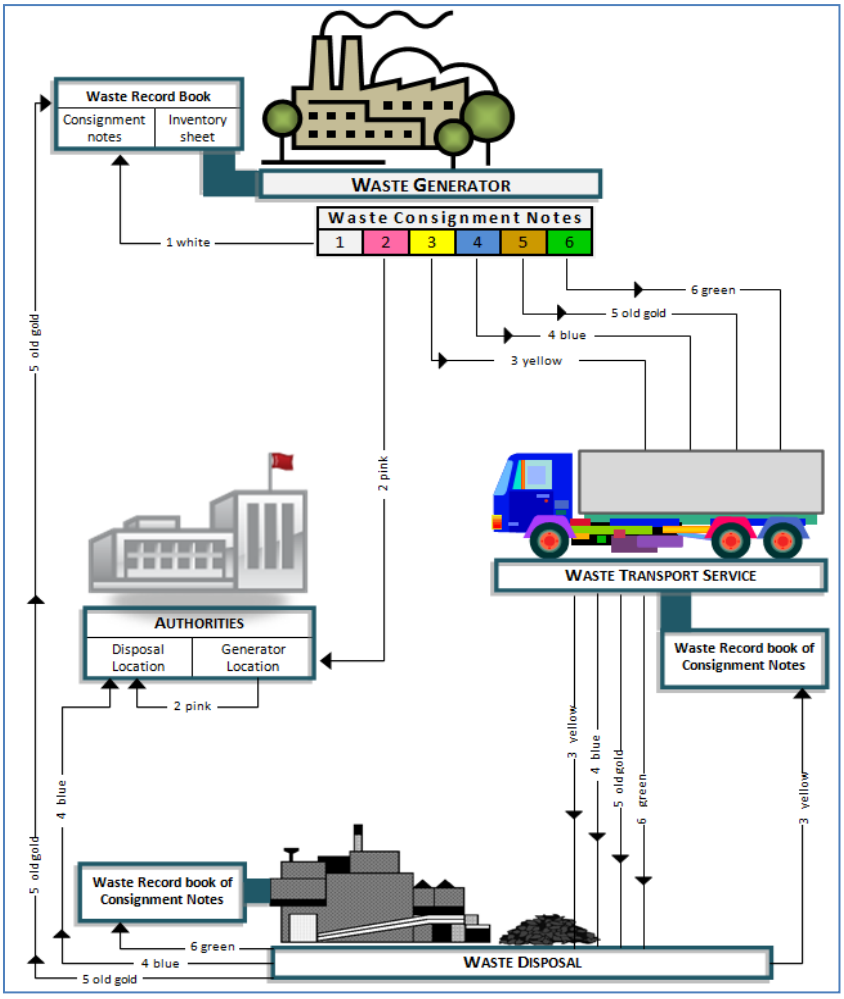


Figure 4.11 *Overview map of the hazardous waste consignment notes.*[6]

[6] *No citation available. A copy of this diagram was provided during the interview with Environmental Management Representative of TK-Hagen*

4.4 INDUSTRIAL PLANT IN SAN LUIS POTOSÍ, MEXICO – TK-SLP.

4.4.1 Plant overview.

Name: ThyssenKrupp Bilstein SASA S.A. de C.V.

Plant Address: Eje No. 124. Zona Industrial, 78395, San Luis Potosí, Mexico

The plant *ThyssenKrupp Bilstein Sasa* manufactures coil springs and stabilizer bars as well as corresponding assemblies. It is the NAFTA plant (*North American Free Trade Agreement*) of ThyssenKrupp Bilstein Suspension and serves customers in the US, Mexico and Canada like Volkswagen, Mercedes, BMW, Ford, GM, Chrysler and Renault Nissan.

The company was founded as a supplier for Volkswagen Mexico in Mexico City in 1968. It was transferred to San Luis Potosi in 2001 (ThyssenKrupp AG ©, 2009).

Figure 4.12 *Front entrance of TK-Hagen industrial plant. (Photo: Puga, J.L., 2010).*

The plant TK-SLP is located in the industrial zone of the city of San Luis Potosí, México next to another plant also part of *ThyssenKrupp AG*. This area is designated by law only for industrial companies and there are no households, schools or commercial establishments in the surroundings.

As done in TK-Hagen, the following description of TK-SLP EMS management, regarding the hazardous substances management in the processes of: Pre-Treatment, Coating and Wastewater Treatment, has been done from first hand information obtained from interviews with *ThyssenKrupp Bilstein SASA* personnel and also personal observation on plant visits. The gathering of this information was part of the first fieldwork research done between June 26th and 30th, 2009.

4.4.2 Environmental quality plant certification.

Contrary to what has been stated from the TK-Hagen manager, TK-SLP environmental management has no connection with the one available on the intranet of the *ThyssenKrupp Bilstein Suspension* group. This marks communication difficulties between ThyssenKrupp Bilstein Suspension group plants and therefore, a main issue that may affect this company's EMS effectiveness.

Nevertheless, TK-SLP environmental management group has developed a handbook that guides the plant's Environmental Management System. This handbook was revised and published in 2008, the actual approved version is the sixth revision of the document. This document establishes the environmental guidelines and principles and was still valid by June 2010.

The EMS of TK-SLP was certified in December 2008 by ABS Quality Evaluations, Inc., a third-party certification company accredited by the Mexican Accreditation Entity (EMA). This EMS is certified in conformance with the requirements set forth by ISO 14001:2004 and is applicable to manufacture for stabilizers and coils springs. This certification expires on October 2011.

At the present time, TK-SLP has promoted an integration program among the Environmental Management System and the Occupational Health and Safety System, following the BS OHSAS 18001:2007 standard. This integration enhances similitude of the EMS implemented in TK-SLP and the one actually running in TK-Hagen. However, this program has not been implemented yet.

Environmental Policy (ThyssenKrupp Bilstein Sasa, 2008)

ENVIRONMENTAL MANAGEMENT SYSTEM - ISO 14001
Environmental Policy

Thyssenkrupp Bilstein Sasa dedicated to the design and manufacture of products for automotive use, is engaged to undertake the prevention of environment deterioration through continuous improvement and legal and other environmental requirements compliance applicable to its operations, as well as environmental protection diffusion through training activities.

We protect the environment by detecting environmental impacts and setting objectives to:

- Pollutants emissions reduction, and
- Efficient use of natural resources.

Management System principles (ThyssenKrupp Bilstein Suspension GmbH, 2009)

THYSSENKRUPP SASA BISLTEIN
Environmental Objectives 2008

1. Reduce energy consumption on the coating process of the stabilizers production line.
2. Replace the use of 4,000 litters of drinking water for treated wastewater on the pieces cooling processes.
3. Reduce Natural gas consumption from the Hook burner equipment on the coating process of the stabilizers production line.
4. Reducing energy consumption on general lighting in the plant.

4.4.3 Chemical Substances involved in the industrial process to study.

4.4.3.1 Inputs and outputs substances. Hazard levels to consider.

In the processes of Pre-treatment, Coating and Wastewater Treatment performed in TK-SLP, there is a list of about 17 different chemical substances, from which 15 can be considered as Hazardous materials regarding the reported properties on the Material Safety Data Sheets (MSDS) from the supplier companies of such substances.

The information from the corresponding MSDSs is resumed on Table 4.3, which indicates the main potential hazard of the components of these substances, as well as other hazards that the use of those substances imply.

As it can be noticed the list is larger than the one of TK-Hagen. The reason for this is, as mention before, that TK-SLP holds an extra production line than TK-Hagen which is the Stabilizers manufacturing. In this line, the substances used for the Pre-Treatment are the same that the ones used on the Coil springs, but the ones used on the Coating process are different, due to the different use of stabilizers and the different processes they pass through *(see Figure 4.5).* For example, stabilizers tips are painted with an acrylic paint in order to obtain a less thick than the obtained layer on the rest of the piece.

Additionally, it can also be noticed that the Wastewater Treatment process includes not only the use of a cationic resin as done in TK-Hagen, but iron (III) chloride which is also used as precipitation agent to improve phosphates removal, which is a common procedure that has been widely used on WWT (Tchobanoglous & Metcalf & Eddy., 2008).

Moreover, it can be noticed also the use of additional chemical substances to regulate pH values on the process as well to obtain deionised water, for example the Primer 40 and Sodium Hydroxide.

Table 4.3 *Input Chemical Substances used in studied processes in TK-SLP.*

PROCESS	SUBSTANCE	MAIN COMPONENTS	MAIN HAZARD	OTHER POTENTIAL HAZARDS
Pre-Treatment	*Fixodine ZN*	Titanium inorganic salts	*No particular hazard*	Exposure would cause irritation with only minor residual injury
	Primer 40	Sodium hydroxide solution	Toxic	Poison and reactive
	Acelerator 131	Sodium nitrite solution	Oxidant	Reactive and minor health toxicity
	Bonderite 952R	Nickel and zinc phosphates	Corrosive	Intense or continued but not chronic exposure could cause possible residual injury
	Chemacid	Phosphoric and nitric acids	Corrosive	Toxic - Short exposure could cause serious temporary or moderate residual injury
	Deoxylyte 54NCA	Diluted fluorzirconium acid	Toxic	Irritant
	Parco Neutralizer 700	Ammonium bicarbonate	Toxic	Irritant, might cause conjunctivitis
Coating	*Corvel Gray Zn Epoxy*	Epoxy resins, zinc phosphates and barium sulphate.	Toxic	Explosive in powder dense atmosphere Might cause baritosis
	Corvel Black 20	Acrylic polymers and carbon black	Toxic Cancerogen	Irritant Chronic exposure might cause cancer.
	Esmalte Brillo Mate Negro	Carbon black, strontium chromate, organic aromatic solvents (xylene, toluene, metilisobutilcetone).	Toxic Cancerogen	Irritant Chronic exposure might cause cancer.
	Black Epoxy PCM90133	Epoxy resins, Carbon black and Barium sulphate.	Toxic Cancerogen	Irritant Chronic exposure might cause cancer. Explosive in powder dense atmosphere Might cause baritosis
Wastewater Treatment	*POLIFLOC*	Polyacrylamide cationic flocculant	*No particular hazard*	Exposure would cause irritation with only minor residual injury
	Iron (III) chloride	Inorganic salt (acid)	Irritant	Intense or continued but not chronic exposure could cause possible residual injury
	Promoclean HCl	Hydrochloric acid	Corrosive	Short exposure could cause moderate injury
	Calcium hydroxide	Inorganic alkali	Irritant	Intense or continued but not chronic exposure could cause possible residual injury
	Chlorhydric acid	Inorganic acid	Corrosive	Short exposure could cause moderate injury
	Sodium hydroxide	Inorganic alkali	Corrosive	Toxic - Short exposure could cause serious temporary or moderate residual injury May react violently with water.

**Hazardous substances are the ones marked with gray shadowed rows.*

4.4.3.2 Hazardous Substances Management I. Personnel safety measures.

With the aim of reducing the potential impact and preventing damage from these dangerous substances on human's health, TK-SLP include some safety measures which were identified on the visual inspection done on the fieldwork of this research.

In the same way that is done in TK-Hagen, workers in TK-SLP pass through training programs to inform about the procedures that they would perform, safety measures that they must take in order to prevent accidents, and who should they notify in an emergency situation.

Furthermore, TK-SLP counts with an "emergency responding team", formed by the selected workers of the same plant and directed by the manager of the Environment and Safety Department in TK-SLP . This team is in charge of attending and monitoring emergency situations (e.g., fires, explosions). They attend to fire-fighting scheduled programs and practices to learn how to act in such circumstances.

On matter of personnel health and safety protection, it was noticed that all workers in the production area of the plant TK-SLP must wear the company's approved uniform and other safety accessories, in order to minimize impact on worker's health and personal integrity, as:

- Cotton pants (jeans)
- Cotton shirt (with *ThyssenKrupp Bilstein SASA's* logo)
- Safety glasses
- Safety boots
- Foam earplugs
- Disposable face mask
- Industrial apron
- Latex glove

Nevertheless, it is suggested higher surveillance on respiratory protection, in addition to a revision of the respiratory protection equipment used in the company for workers in the Coating process, taking into account the recommendation on the Safety Data Sheets of the substances managed in this process.

4.4.3.3 Hazardous Substances Management II. Environmental management.

SUPPLIERS RESPONSIBILITY.

TK-SLP has an established selection procedure for choosing their services and materials suppliers. In the same way as mentioned by TK-Hagen administrators, TK-SLP requires a sort of certification from all these companies according to their service provided. However, as in TK-Hagen, there is no specification of environmental certification requirement for materials suppliers, but it is required

to count with certification on a variant of quality management system (e.g., ISO/TC 16949:2002, ISO 9001:2002).

On the other hand, industrial services like laboratories are required to be certified in compliance with standards on testing and calibration laboratories (e.g., ISO/IEC 17025:2005). In the same way, auditing services must prove certification on management systems (e.g., NMX-SAA-14001-IMNC-2006).

Besides certification, TK-SLP has an evaluation system, involving candidates' documents revision and visits to the company's location. After the evaluation procedure is completed, TK-SLP grades the company's compliance with their requirements, in a scale from 0 to 100 as shown on Table 4.4 deciding then if the candidate becomes a TK-SLP's official supplier. These grades are revised each six-months.

Table 4.4 *Possible suppliers' grades on TK-SLP's evaluation.*

OBTAINED GRADE	RESULT MEANING
90 – 100	Excellent
70 – 89	Satisfactory
60 – 69	Regular
50 – 59	Conditional
00 – 49	The company is rejected or unregistered as TK-SLP supplier.

STORAGE CONDITIONS AND SAFETY MEASURES.

The information corresponding to the storage and handling of chemical products is indicated in the TK-SLP implemented EMS, in the document *IRH – 010*, named "Management and storage of chemical products" *(Manejo y Almacenamiento de Productos Químicos)*. This document includes information about:

- Chemical substances list (used in all TK-SLP processes)
- Authorized personnel
- Use of personal protection equipment
- Storage indications (instructions for suppliers and reception personnel)
- Storage site characteristics
- Management of inputs and outputs of substances from the storage site
- Emergency attendance on case of substances' spills and leakages
- General safety measures

All acquired chemical substances are stored in their original packages as delivered by supplier, they are kept in the company's chemical substances warehouse outside the plant area of TK-SLP.

The characteristics of this storage site, as well as chemicals' containers conditions, are described according to what has been observed during the plant's visits held in May, 2010:

a. Hazardous substances' containers were properly sealed, seemed not old, they were not damaged or unidentified. Moreover, these containers were properly labelled including substances hazard information and the NFPA fire diamond.
b. The only substance's container did not count with proper identification, seemed old and at least one of the containers was not properly sealed was the POLIFLOC, used as cationic resin in the flocculation process of WWT (see section 4.2.3). However, according to the corresponding MSDS information (see section 4.4.3.1), this substance does not represent significant hazard either to workers health or environment integrity.
c. Containers are arranged separately, in groups of the same substance, and located against the storage-site walls, over which are also visual signs with substances' names and hazard identification.

The warehouse is located outside the company's production plant, it has concrete walls and metallic ceiling, which is around 40cm over the walls top, letting air flow into the warehouse that works as a ventilation system, avoiding also heating inside the structure. The site floor was dry, and there was no sign of substances' spilling or leakages from containers (in compliance with NOM-006-STPS-2000).

As safety measures, the site is kept under lock with only authorized personnel access, it counts with an emergency canalization system and fire warning and safety equipment protection signs.

USE AND ACCIDENT MEASURES.

The stage of "Use" of each substance starts from the moment it is been taken out from the storage site. Therefore, in the EMS of TK-SLP is included a documented procedure, the ISE-221, Chemical Products Management *(C.C. Manejo de Productos Químicos)*, that contains instructions, safety measures to take into account and personal protection equipment to wear, when chemical products containers are moved out from the storage site and substances are being deposited in the corresponding tanks of the production line.

Then, yet in the production line tanks, the substances are being used as described on section 4.2, on the different description of processes of interest. The hazard level to which workers and environment are exposed is described on Table 4.3.

The following notes have to be taken into account, in order to complement this information for the TK-SLP study case regarding the hazard chemical substances use:

- Machinery that involves the use of chemical substances has its corresponding risk awareness signs (using the NFPA diamond).
- Substances used during the steps of Activation, Phosphatise and Passivation are manually added to the corresponding containers, using as self-protective equipment as masks, latex

gloves, safety glasses and industrial apron; these collectors contained deionized water which, mixed with the substance, is pumped into the tunnel of the process and the sprinklers.

- In the same way, in the coating process, powder paint is manually taken from the collectors and deposited in the corresponding machinery, using small shovels, masks, latex gloves and safety glasses.
- Non-fixed substance is recollected, sieved and reused, in order to avoid materials looses or the increase on waste generation. This is done as explained in section 4.2.2., collection of non-fixed powder is done automatically by cyclones (in the coil springs production line) and manually (in the stabilizers production line).
- As in TK-Hagen, the coating tunnel is located inside coating cabins, which works as physical barriers against dust spread in the plant's atmosphere. Nevertheless, the paint particles' concentration inside those cabins is unknown; therefore, it is recommended to carry out a dust analysis of the intern atmosphere of the cabins, in order to identify whether the working atmosphere does not represent significant danger for workers' health, or the need of different safety measures, like special respiratory equipment in the Coating cabins.

Additionally, according to the information from interviews with the workers in TK-SLP plant, some elements to consider are:

- Dangers that workers identify relating the use of hazardous substances are mainly those that cause immediate or short term damage, as: acid burns, eyes irritation from fumes and throat irritation and/or breathing problems from chemicals dust. This coincides with some of the identified hazards on Table 4.3; however, awareness of chronic exposure damage (e.g., cancerogenic toxicity) or environmental impact is not identified from the workers standpoint.
- From training programs, workers identify two main actions in emergency cases: (a) against spills, they must recollect the substance using special shovels, floor wipers and buckets; then direct the remaining to the emergency canalization system; (b) when leakages are identified, they have to warn the shift supervisor.

On other hand, regarding company's general environmental behaviour, there exist records about the compliance with other regulations on environmental matters, like the analysis of treated wastewater from the biological WWT plant (which works separately from the one for the Pre-Treatment process) and compliance with limits on pollutants concerning atmospheric emissions. However, atmospheric pollution from combustion processes is not considered in this study.

WASTE COLLECTION AND TREATMENT (INSIDE THE PLANT).

The waste generated and collected from the processes of interest in TK-SLP are:

- *Wastewater:* collected from the different stages on the Pre-treatment process;
- *Paint dust:* non-reusable powder paint, collected manually from the Coating equipment and cabins maintenance;

- *Aerosol painting cans:* Empty containers of aerosol painting from the finishing touches at the end of the stabilizers Coating process.
- *Industrial garbage:* empty paint cans, solvent and paint stained stuff, among others, collected from the identification stage.

The collection methods for the last three types of waste, follow the documented procedures, part of the plant's EMS: IAM-001, IAM-018 and IAM-021 respectively. However, only wastewater receives treatment inside TK-SLP's plant.

WWT in TK-SLP is held similarly to the one performed in TK-Hagen *(see section 4.2.3)*. Then, with the supporting literature background of the method, it is supposed that the process reduces concentrations of the pollutants of interest. Treated water is used for irrigation in the green areas of the TK-SLP plant. Final obtained sludge is managed according to the documented procedure *IAM-017: Phosphate sludge control*, included in the EMS of TK-SLP plant.

However, less can be said about the effectiveness of such treatment due to the lack of control on evidential documents or laboratory analysis.

Final collected waste is deposited in metallic cylindrical containers, identified and labelled including the following information:

1. Date of send.
2. Waste Generator data (e.g., name, address, telephone, production area, authorization signature).
3. Destination company data (e.g., name, address, telephone).
4. Handling safety requirements - Personal protection equipment.
5. Hazard identification (CRETIB code).

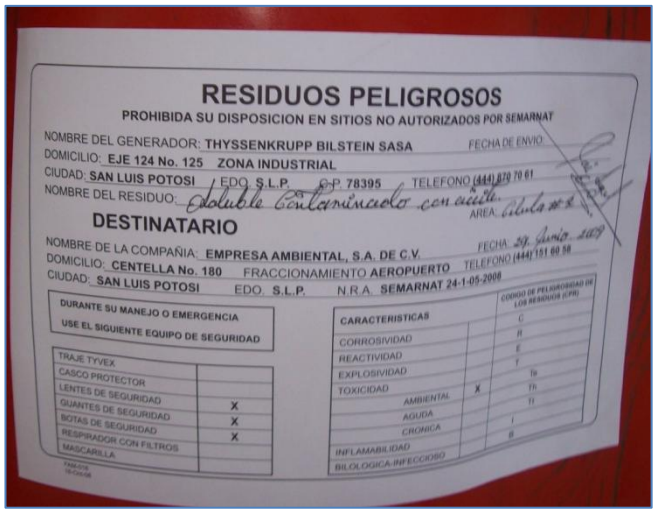


Figure 4.13 *TK-SLP Waste collection and management. Example of Waste collector label.*

FINAL GENERATED WASTE INTERNAL MANAGEMENT.

As mentioned before, the waste from the different processes of study in this research is collected and classified in two types:

1. ***Non-dangerous waste:***
   Fine Paint Dust: Collected dust from the cabins on the Coating process that cannot be reused (see Figure 4.4 and 4.5).

2. ***Dangerous waste:***
   a. Sludge from Pre-Treatment: Identified as "Phosphate sludge", obtained from the WWT of the Pre-treatment process (see Figure 4.7).
   b. Aerosol painting cans: Empty containers of aerosol painting from the finishing touches at the end of the stabilizers Coating process (see Figure 4.4 and 4.5).
   c. Industrial garbage: Dry paint and contaminated materials with paint, grease and solvents from the identification stage after the Coating process (see Figure 4.4 and 4.5).

The classification of "Fine Paint Dust" as Non-dangerous waste is supported by a certified laboratory's CRETIB analysis, performed on December, 2005. The results indicates that this kind of waste has no corrosive, reactive, explosive, toxic or biologically infectious properties, under the procedures and parameters established on Mexican regulations NOM-052-SEMARNAT-1993[7] and NOM-053-SEMARNAT-1993.[8]

Though these results, with a reflective analysis on the process and possible chemical changes, the resulted paint dust keep original hazard properties reported in the corresponding MSDS. Therefore, it is suggested to make a second analysis, by a different authorized laboratory, that corroborate or refute these results.

On the other hand, even though there is not analysis of the sludge from the Pre-Treatment process, empirical knowledge is sufficient to support its classification as "dangerous waste". According to the Mexican ordinance of the General Law for Waste Prevention and Comprehensive Management (LGPGIR), it can be identified as "dangerous waste" that which is resulted from processes involving HS or their combination.

All containers are placed in a temporal storage outside TK-SLP plant. This Temporal Waste storage zone is delimited by a metallic fence and protected for sunlight and rain by a metallic ceiling. There were identified some precautionary measures like: safety drainage, fire extinguisher, and visual identification of different types of waste and restriction signs for only authorized personnel. Such characteristics support site's compliance with the requirements of NOM-005-STPS-1998 and the

[7] *NOM-052-SEMARNAT-1993 - Which establishes the characteristics of hazardous wastes, the list thereof, and the limits that make a waste hazardous due to its toxicity to the environment*
[8] *NOM-053-SEMARNAT-1993 - Which establishes the procedure to perform an extraction test for determination of constituents that defines a hazardous waste due to its toxicity to the environment.*

ordinance of the LGPGIR (as well as other additional regulations cited in Chapter II, section 2.4.3.4).

(a) 

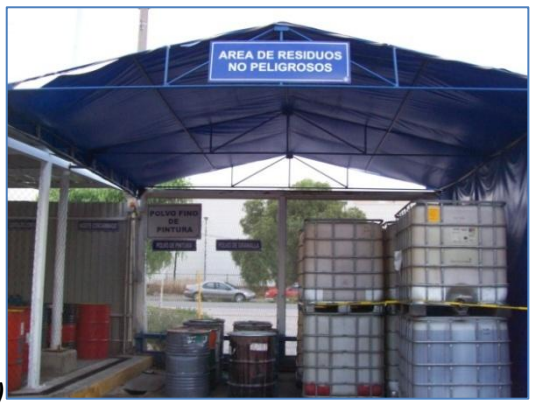
(b) 

Figure 4.14 *Temporal Waste Storage in TK-SLP: (a) Dangerous Waste (b) Non-dangerous waste.*

SPECIAL WASTE COLLECTION SERVICE AND FINAL DESTINATION RESPONSIBILITY.

Waste collection in TK-SLP is done by company authorized by the Ministry of Environment and Natural Resources *(Secretaría de Medio Ambiente y Recursos Naturales, SEMARNAT)* which works as an intermediate.

As general requirements that TK-SLP establishes to accept the services from a Waste Collection Company can be mentioned:

1. Management quality certification, e.g., ISO 9001 (as seen in section 4.4.3.3).
2. Currently valid authorization from SEMARNAT (a copy is required for the EMS records).
3. Safe transportation service and driver's special license for hazardous waste transportation.
4. Supporting documents for the verification of the following stages on waste management, specifically the signed copies of the *Waste Manifesto* from the transport service and the receiver company, in compliance with the ordinance of the LGPGIR.

Figure 4.14 indicates how are the Waste Manifesto and its copies handled, according to the ordinance of the LGPGIR. However, it is worth mentioning that, actual waste collection and management may involve more companies, like in the case of TK-SLP.

In this case, waste is received and temporally stored by the first *receiver company* (or transference station) until the amount collected from different companies reaches certain volume. Then, it is sent to a larger temporal storage in another transference station, which finally sends it to an incineration company that uses waste as combustible materials for ovens in the Cement Industry.

Though, TK-SLP counts with copies that demonstrates SEMARNAT's authorization of these companies practices, there was not clear information about whether both, dangerous and non-

dangerous waste, go through the same stages until its final elimination; or, if non-dangerous waste is finally confined in a different location.

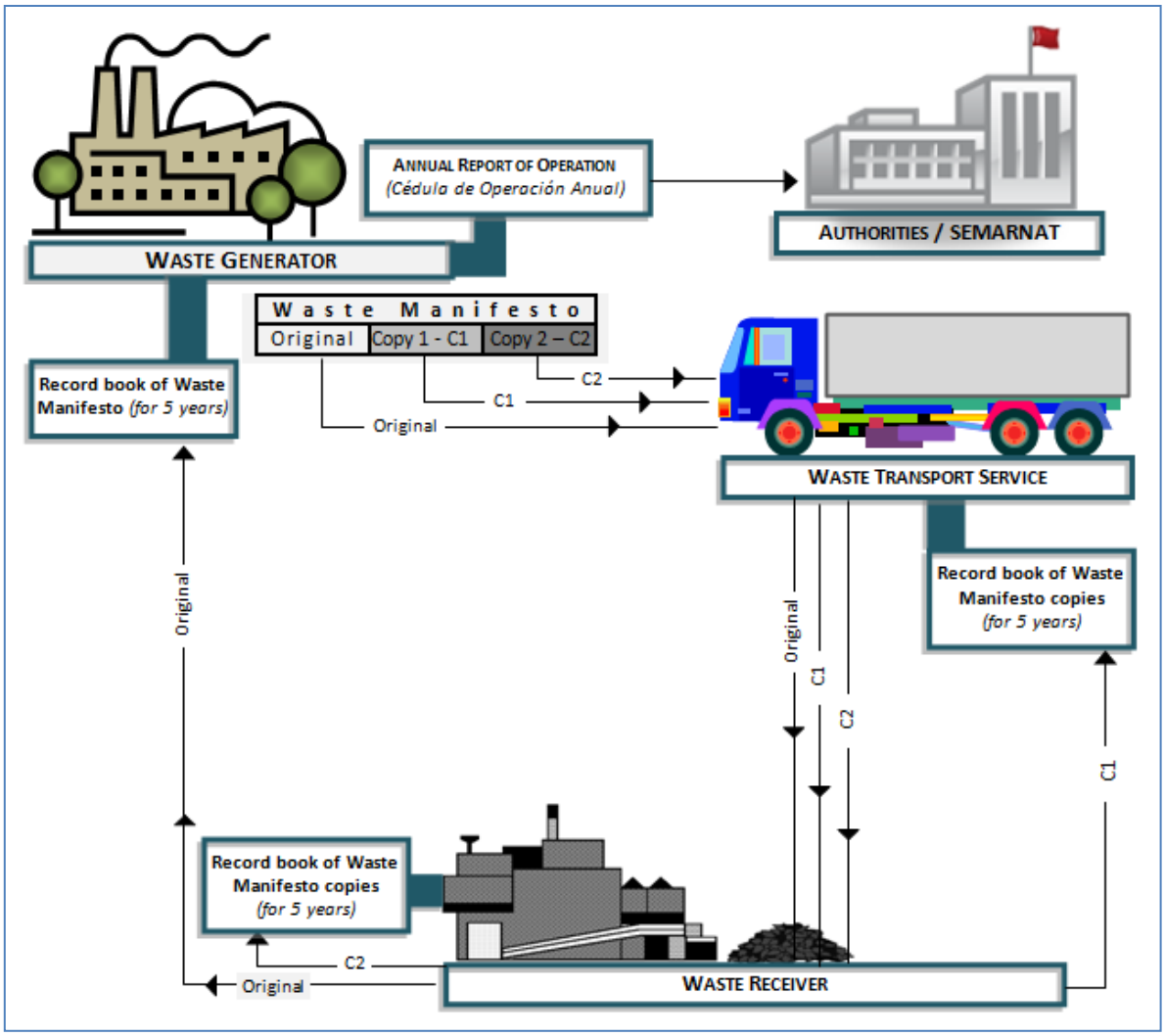


Figure 4.15 *Stages of generated waste until final elimination (Based on the LGPGIR regulations, 2007)*

CHAPTER V.
THE EMS EVALUATION TOOL

In this section the main question would be*, how good is the EMS of the company when talking about hazardous substances (HS)?, what are the real aims of its implementation and maintenance?, and how far is the company going through a continuous improvement process in order to assure that this substances won't represent a danger for the society and environment?*

For this reason, first it must be defined two important concepts: Environmental Management Systems and Continuous Improvement process. Then, noticing the existence of differences on levels of appropriate environmental behaviours and the different perspective in which HS can be identified as such, it's been presented a proposal of characterization tool that qualifies the environmental behaviour of a company's EMS regarding its HS Management.

5.1 EMS OF HAZARDOUS SUBSTANCES EVALUATION TOOL. BASES AND FOUNDATIONS.

5.1.1 What is an EMS? And what means a "continuously improved process"?

As mentioned before an Environmental Management Systems (EMS) can be understood as a collection of elements like: actions, procedures, organizational structure that aims to comply with an environmental objective in a organization.

Many companies take international standard guidelines (e.g., ISO 14001 or EMAS) in order to develop, implement, demonstrate and maintain an EMS. In these cases, the company pursuits a public recognition of this effort and becomes internationally "certified" in their compliance with the elements established in the norm.

Nevertheless, nowadays many organizations do not count with a documented Environmental Management Handbook, or an organized collection of documents and well-defined and structured team of people in charge of those activities, but it does not really mean the absence of an EMS.

In many countries, most of the companies must fulfil some legal environmental requirements in order to avoid payment of pollution fees, or also to prevent future costly (economical, environmental or human life risk) accidents. In behalf of this, companies keep some records, introduce workers training safety programs and emergency plans and wastewater treatment or end-of-pipe technologies to avoid over-passing legal limits values of pollution. All this can also be considered as part of the EMS of an organization, even if does not exist a proper or documented one.

The **Continuous Improvement** goal in a company is set in its quality management objectives, and on the contrary with EMS this concept is always planned and a conscientiously action. In basic words it only means to do the same activity in a better way every time or in a certain period of time. Coming again with international guidelines, it can be defined as:

"Recurring process of enhancing the environmental management system in order to achieve improvements in overall environmental performance consistent with the organization's environmental policy" (*DIN EN ISO 14001:2004*, 2009)

Environmentally talking, this definition can be taken from different points of view, thus be reflected on companies objectives to direct different environmental actions with different purposes. To explain this, this is an example:

A company counts with an environmental policy which "assures" proper environmental behaviour by committing the company to avoid environmental severe impact recurring to legal limits of pollution. Hence, their targets and activities would be directed to this, maintaining pollution bellow those limits even by introducing technology to do it in an economic way, also they can adopt emergency plans to avoid and/or protect environmental impact and people's life and health in case of accidents. By time, they keep with these actions and reduce the number of accidents, and probably maintain their discharges below the legal allowance limits.

By analyzing this case, it can be seen that the company focus its actions on achieving the proper environmental behaviour set by the region's legal requirements, but it doesn't necessarily means an adequate environmental performance, since in some countries, most of them with intensive industrial activity, the legal allowance limits for atmospheric emissions, wastewater discharges and soil can be too weak leading companies to avoid introducing advanced technology that would lower their actual limits.

It can be also said that the company achieves its continuous improvement goal by reducing the number of accidents related to environmental danger. However it doesn't really mean that their environmental performance it's getting better with time, meaning that a "continuous improvement" goal leads the company to choose what should be improved and how should it be done.

As resume, this company meets the environmental behaviour required by law, so far there won't appear any complaints from thirds parties until the law is modified.

5.1.2 Is it enough to achieve only legally accepted environmental behaviour?

As simple as it may seem, this has not been an easy question to answer through the last 40 years. Since environmental laws have been introduced in many countries, many industrial companies had to make huge investments on end-of-pipe technologies to comply these requirements.

But these legal changes have come only because of the acknowledgment of the environmental and health effects that past activities had; like the toxicity of DDT and PCB as pesticides, since in the first case, it was banned after 30 years of widespread usage and study of its persistence, transport, biomagnifications and toxicological effects *(see Figure 5.1).*

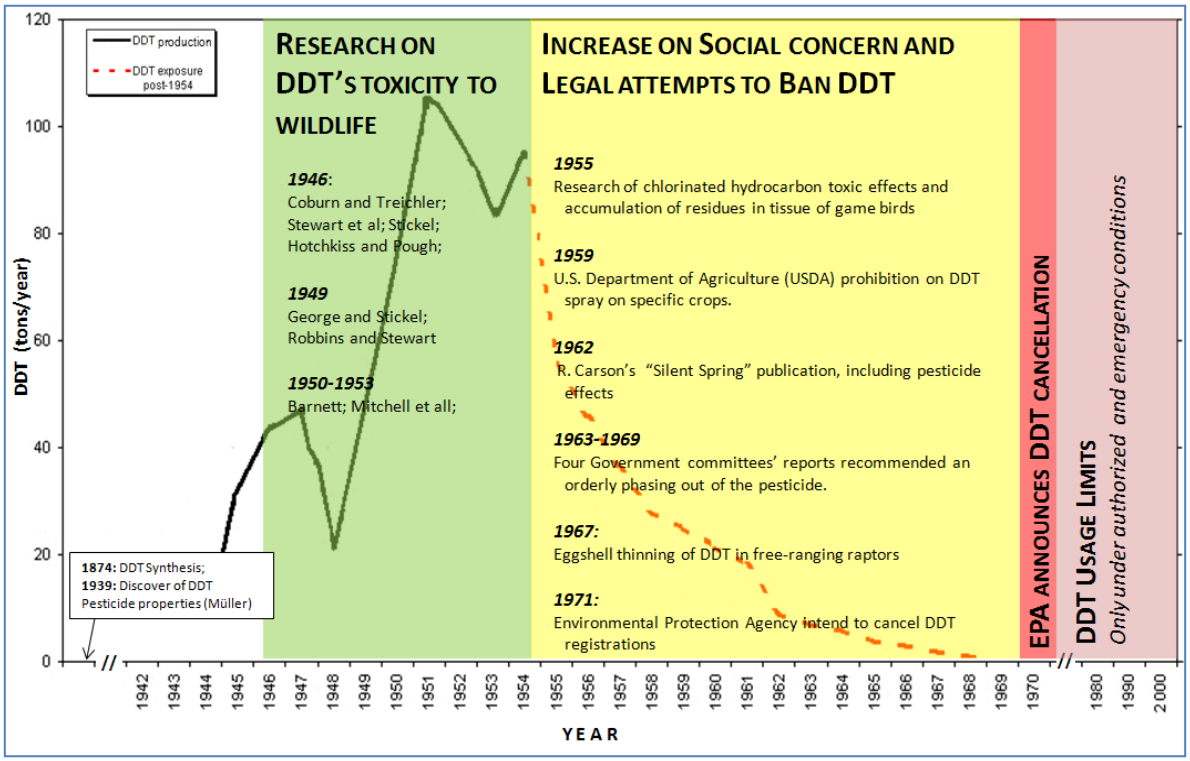


Figure 5.1. *DDT research and regulatory history*
(Modified from: Hayes and Laws, 1991, cited in West, 2003. Additional information: EPA, 1975; Rattner, 2009).

Similar cases lead to the prohibition of Lead in paints, restrictions in the use of Asbestos and Benzene, among other examples that had caused legislation changes, due to the demonstrated impact that chemicals have on humans' health and the environment integrity. Then, regarding this past history, *who says it may not happen again?*

Until now, some countries take into account the World Health Organization (WHO) established limits that describe the minimum values of these pollutants that have demonstrated to have an impact on human's health. But these limits don't include synergetic effects of pollutants in the human body. Furthermore, year by year more chemicals are released into the market and their toxicity is not yet well known and so, they are not included in actual regulations.

So the answer would be no; in past, legal regulations were not sufficient to protect human health and environmental integrity, then they changed due to the revealed negative impact. From it, can be seen that some severe negative impact delay long time in appear, so legislation cannot be updated as fast as these substances' effects appear, that makes them insufficient and unreliable as health and environmental keepers.

5.1.3 How to differentiate environmental behaviour?

As said before, environmental performance can be different from one organization to another. For example, while some companies introduce end-of-pipe systems to reduce the final waste products (emissions or pollutants on water discharges) in a way that they stay below legal allowance limits, others ones invest time and resources not only to keep them below those established limits but go further those legal requirements; then, others are change inputs as solvents and combustibles, or recycling and recovering materials.

Thus, even these companies are doing what is environmental legally required, it cannot be said that all of them have the same environmental behaviour, nor the same concern on environmental protection or the same environmental objectives.

So it is important to have a tool that helps to establish the actual organization's environmental situation and show the future path it could follow; all this would lead to the description of the company's environmental behaviour.

In order to do this it is important to take into account important environmental principles, which as mention before, have also guided environmental legislation in some developed countries (i.e., in Germany. *See Chapter II, Section 2.4.2*). Recalling then:

- **Precautionary principle (PP),** a popular term worldwide known, but with many definitions that can lead to some differences in its understanding. The definition of the EU is:

"The precautionary principle applies where scientific evidence is insufficient, inconclusive or uncertain and preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal or plant health may be inconsistent with the high level of protection chosen by the EU" (EU, 2000; cited in "The Precautionary Principle," 2005)

- **Polluter-pays-principle,** meaning that pollution is generator's responsibility, thus they must be aware of the environmental impact their activities involve, reduce them pay and repair damages.

- **Cooperative principle**, which remarks the involving of civil participation on the decision making process when people is exposed to specific needs related environmental issues.

From these principles, the one to focus in this proposed method is the PP, which has been a worldwide discussed subject and has been adapted in different forms by many countries. The general concept involves one single message: *"Be prepared"*. There are many hazards when chemicals are involved, even sometimes when there is no scientific evidence of such danger. The best way to actually follow this principle would be by pursuing the continuous reduction, elimination and ultimately avoidance of pollutants discharges and emissions, so the environmental impact would also be reduced.

5.2 GROUPS AND ELEMENTS OF EVALUATION. RELEVANCE, BASES AND DESCRIPTION.

The evaluation aspects to consider in this proposal of EMS evaluation method, regarding Hazardous Substances Management in an industrial company, are presented from a general to a specific focus area. The idea of having this structure is to start with a general understanding of the organizational elements as the bases of the company's EMS. This is because all further activities must be directed to what the company has already set on their environmental policy, even that in some cases this is not actually done.

Therefore, the proposed evaluation is organized in two groups which together include a total of nine sectors and, for each sector to analyze, a group of elements for evaluation. Figure 5.1 shows a scheme that describes better the organization of the proposed evaluation methodology of this research.

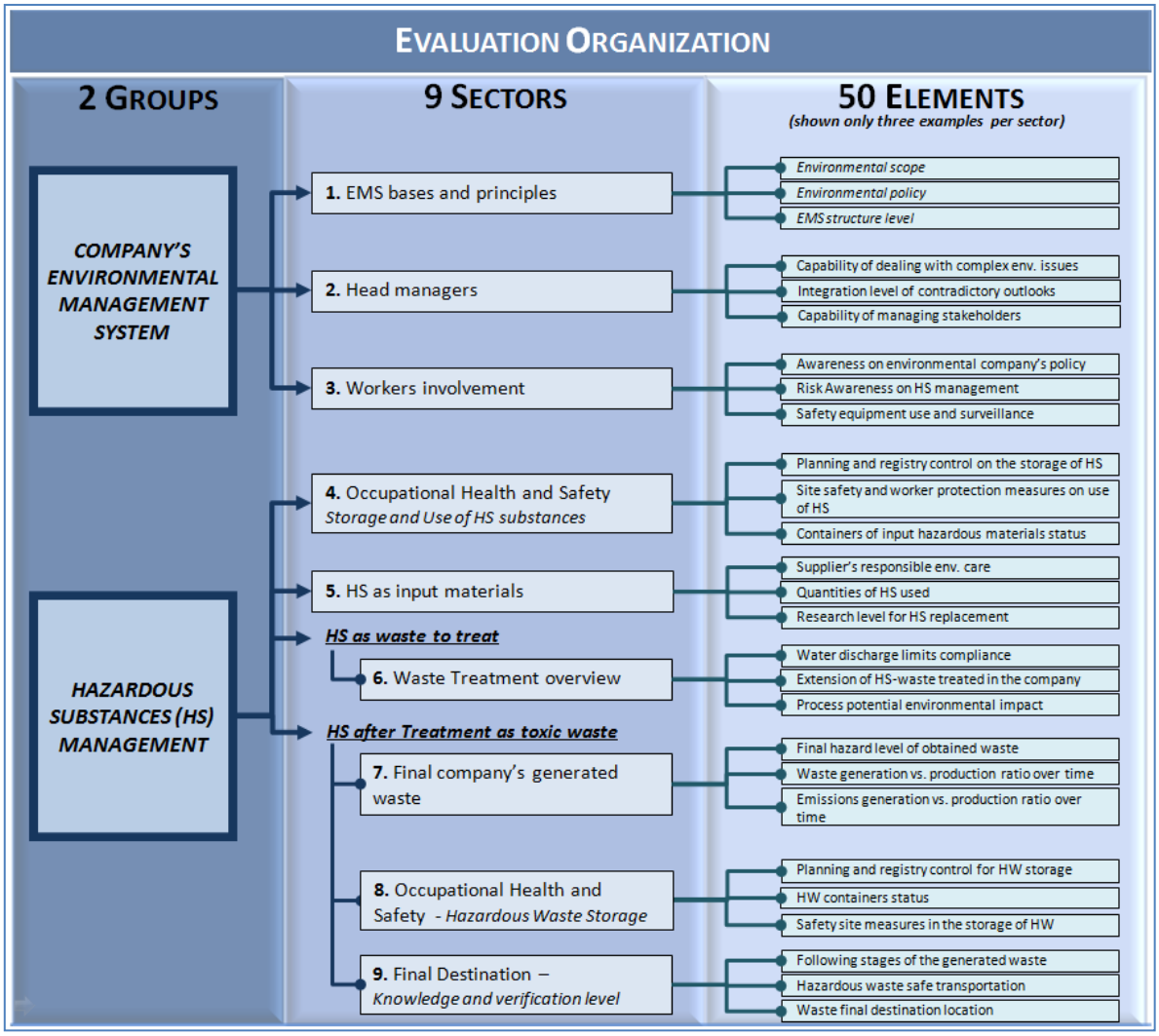


Figure 5.2 *Evaluation proposal. Organization of groups, sectors and elements of evaluation.*

Then, regarding the elements per sector of analysis, at the end there are 51 different elements to evaluate. Each of these elements corresponds to formulated questions on structured interviews or elements to examine during visual inspections, integrated in descriptive checklist applied during the evaluation of the company's EMS on hazardous substances (HS). The objective is to grade, or more precisely to classify them, according to the different proposed environmental behaviour that a company may present.

In this section evaluation groups and sectors are described, indicating its relevance and the corresponding elements of evaluation, and therefore, justifying its inclusion in this proposed method of evaluation of an EMS on HS.

5.2.1 Company's Environmental Management System description group.

The objective of starting with a general analysis of the company's EMS is to understand the bases of management and the environmental framework in which the Hazardous Substance are handled.

Then, the information obtained would help to define how structured is the company's EMS, how actually committed are the members of it, how are environmental matters seriously taken into account as a company's priority and how strong or weak is the communication channel among different levels of organization, which at the end would lead this system.

All those elements are basic constituents of an EMS, following the guidelines already viewed on Chapter III, section 3.1, and their correct functioning would facilitate the "Check" stage of an EMS base methodology that follows the standard ISO 14001:2004.

Then, it is precisely the functioning of the EMS what is wanted to identify in this group of evaluation, since the Hazardous Substances management (which is the centre of this proposed methodology of evaluation) is directly related with the company's environmental and safety matters.

Taking this into account, it can be supposed that if the EMS has a solid structure following the existent guidelines (e.g., EMAS, ISO 14001), it is consistently and effectively implemented, then there is less probability of having unconformities in the HS management. On the other hand, when there are problems in the core EMS organization, there are surely also problems in the Hazardous Substances Management of the company.

5.2.1.1 Company's EMS bases and principles.

The first stage of the analysis has the main purpose to get a general idea of the company's posture on Environmental responsibility and awareness on the environmental impacts that can cause the activities held in the company. Such information should become the pillars of the company's EMS, and guide company's decision making process.

On well established EMS this information should be already set on the company's published Environmental scope and policy. However, in these cases it is needed to analyze these statements and compare them with the actual company's behaviour. This implies a more reflective, objective and conscious process from the evaluator.

On the other hand, activities held in companies without a structured EMS are mainly directed to accomplish with minimum legal environmental requirements, present a remarkable lack of organization and therefore, more difficulties to identify legal breaches that eventually could result in accidents that involve people and/or environmental damage.

However in this last case, the evaluator must analyze some important points, like how environmentally oriented is the decision making process, how legal compliance with established environmental requirements is managed, and how workers safety is being considered in the practices that involves contact with Hazardous Substances.

Therefore, the sector **1. Company's EMS Bases and Principles** from the Company's Environmental Management System group (see Figure 5.2) includes the following chosen elements of evaluation, taken from the information on Chapter III section 3.1.3.1:

1.1. Environmental policy (EP) orientation
1.2. Level of structure and organization on EMS
1.3. Sustainability elements in targets and objectives
1.4. Sectors of evaluation influenced by the EP
1.5. Actors involved in established commitments
1.6. Public participation and informing
1.7. Linking level of objectives and planning
1.8. Level of Environmental Indicators
1.9. Motivations of improvement
1.10. Frequency of revision and replanting environmental objectives

5.2.1.2 Head managers.

Since the EMS commitment involves all levels of the organization, the one that receives the mayor responsibility is the Top Management level. Is in this level where the environmental scope and policy are developed, then the planning and implementation procedures depend also from the decisions taken on this level of the organization.

Therefore, on the same way the structure level of the EMS affects its functionality, the top management characteristics would affect it, and consequently the Hazardous Substances Management would be influenced too.

Then, in order to achieve an adequate environmental management, it is needed to count with an authentic environmental interest and the awareness from the manager's side. Thus, it can be said that EMSs require to be managed by "environmental leaders", which as described by Boiral *et al* (2009, pp. 479) are *"aware of ecocentric values, more attentive to stakeholders' expectations, and personally committed to organizational change through various approaches, such as pollution prevention, implementation of management systems like ISO 14001, and heightened employee awareness."*

Since the time Environmental Management guidelines have been introduced in organizations, this "environmental leaders" topic has also been of discussion from several authors, such as: Bansal and Roth, (2000); Delmas (2001); Henriques and Sadorsky (1999); Sharma (2000), among others.

These discussions surround the characteristics that the manager must fulfil (referring at the aspirant of becoming an environmental leader), involving mainly personal behaviour and skills, as well as paradigm orientation on the decision making on the organizations.

Then, taking into account what Boiral *et al* (2009) have mentioned to be necessary characteristics of environmental leaders, the proposed evaluation methodology of this research use them to revise how environmentally oriented is the EMS main responsible profile, concluding then in the sector **2. Head managers** from the Company's Environmental Management System group (see Figure 5.2) with the following elements of evaluation:

2.1 Capability of dealing with the complexity of environmental issues
2.2 Integration level of seemingly contradictory outlooks
2.3 Capability of understanding and addressing expectations of stakeholders
2.4 Capabilities of adaptability and organizational practices change

5.2.1.3 Workers involvement.

Following the management EMS chain, it is not surprising that workers involvement be included in this evaluation methodology proposal, recalling one more time the need to include all levels of the organization in the environmental commitment.

Though this is not formally included in the ISO guidelines, its importance is acknowledged as one of the required elements on the EMAS guidelines. Furthermore, several authors recognize employees involvement as a key element that directly influences on the success of an EMS (Baxter, M., 2007; Stapleton & Glover, 2001).

Moreover, it is significant to consider plant workers on the evaluation of the Hazardous Substances Management, due to the fact that they are the ones who handle the substances, the ones in direct contact with them, and the ones that would immediately suffer the consequence of an inadequate procedure.

Then, referring to industrial practices, workers must be aware on the risk they are being exposed to, be capable of doing their activities following safe procedures and be prepared against accidents and emergencies that can occur during their work.

Additionally, the role of the worker on the EMS functionality is enhanced when Top Management is open to dialogue with them, recognizing the value of workers points of view, supported on self-experience and direct handling of the processes. This decision is often used to help detecting improvement opportunities and, therefore, contribute to the continuous improvement process of the EMS.

For these reasons, the elements of evaluation of sector **3. Workers involvement** from the Company's Environmental Management System group (see Figure 5.2) are:

3.1 Understanding on environmental company's policy.
3.2 Risk Awareness – Identification of HS during process and adequate handling knowledge.
3.3 Use and surveillance of safety equipment.
3.4 Frequency of exposure.
3.5 Risk Communication - Identification of immediate communication link.
3.6 Inclusion of workers comments in the decision making process – Comments, ideas or experiences to improve environmental performance.
3.7 Training emergency programs.

5.2.2 Hazardous Substances Management group.

After understanding the bases of the company that guide their actions and decisions on environmental and workers safety matters, the evaluator can have a wider perspective on the possible issues or difficulties that may be faced in the evaluation of Hazardous Substances (HS) management.

Is in this group that the proposed evaluation focuses its attention, analyzing specifically how are dangerous chemical substances (or products) acquired, stored and handled; and then, how is the generated waste treated, collected and finally disposed.

In order to do this, the following sections describe the last proposed sectors of evaluation in this method in the following order (see Figure 5.2):

1. *Storage and Use of hazardous substances* describes sector:
   - **4. Occupational Health and Safety in the Storage and Use of HS substances**

2. *Hazardous substances as input materials* describes sector:
   - **5. HS as input materials**

3. *Hazardous substances as processes' generated waste describes sector:*
   - **6. Waste Treatment overview**

4. *After Treatment - Final dangerous waste, describes sectors:*
   - **7. Final company's generated waste**
   - **8. Occupational Health and Safety - Hazardous Waste Storage**
   - **9. Final Destination – Knowledge and verification level**

5.2.2.1 Storage and Use of hazardous substances.

The sector **4. Occupational Health and Safety in the Storage and Use of HS substances** from the Hazardous Substances management group (see Figure 5.2) includes the description of the storage and handling of HS (e.g. storage site conditions, personal protective equipment, containers' status and identification).

It is worth to remember that storage of chemicals substances is regulated by law in many countries. When this is the case, authorities state that is the employer's responsibility to provide a safe storage place with such conditions that do not represent danger for workers and environment (see in Chapter 2).

In addition to this, assuring safety in work places is a relevant aspect to consider when it is wanted to evaluate company's awareness on the risk that the involvement of hazardous chemical substances in their practices.

Therefore this sector is dedicated to evaluate chemical substances storage conditions, as well as safety elements on work places. In order to do this, the set of elements of evaluation are:

Storage site:

4.1 Planning and registry control on the storage of HS
4.2 Containers of input hazardous materials status
4.3 Safety site measures in the storage of HS

Chemical products:

4.4 Planning and registry control on the use of HS
4.5 Worker's protection measures in the use of HS
4.6 Safety site measures in the use of HS

5.2.2.2 Hazardous substances as input materials.

In this section, the elements considered in this analysis evaluate how are chemical substances (or products) are managed from at the moment they are been used along the process, until they produce some kind of waste.

While in other previous sections have been already analyzed elements like: safety conditions related to workers protection equipment and storage and work place conditions status *(section 5.2.2.1)*, in this section the selected elements of evaluation focus on the process(es) in which the identified HS are used.

First of all, it is wanted to know if the company takes into account the origin of such substances (or products). This would be demonstrated by the knowledge they care to obtain in their selection process of chemical products suppliers.

After that, the control over the number and use of chemical substances in the company's process(es) would contribute to describe the company's awareness on the risk they involve. This kind of control contributes to company's compliance with legal requirements on the management of HS.

Then, with an attempt to identify some elements of continuous improvement in the use of these substances, this methodology of evaluation applies concepts of reuse, clean technologies and research on the replacement of dangerous chemical substances or different processes that avoid (or reduce) waste the generation.

The set of elements of evaluation chosen to describe the sector of analysis **5. HS as input materials** from the Hazardous Substances management group (see Figure 5.2) are:

5.1 Responsibility from suppliers
5.2 HS substances number and use in the company process(es), including level of hazard
5.3 Level of recovering and recycling or reuse of chemical products.
5.4 Research level on replacement of HS in the process
5.5 Research and Introduction of "clean technologies" in the processes

5.2.2.3 Hazardous substances as processes' generated waste.

After the use of HS in an industrial plant's processes, inevitably there is waste generation. Some of this waste can be treated inside the own company.

This section attends specifically to the treatment HS receive inside the company, how effective is it in order to comply with (either legal or lower-self-established) pollutants limits, and to reach planned objectives in the company.

However, it is important to remark that probably not all generated waste the company can be treated inside the plant; therefore no tall processes are included in this sector of evaluation.

A good example of this is the wastewater treatment, which is required by law to many industrial companies in order to avoid dangerous quantities of pollutants in the different types of waterbodies or city drain.

Though, there can be different ways on treating wastewater, the main objective of all is the same: reduce pollutants concentration. The type of treatment would depend on what kinds of pollutants are wanted to be removed and what is the desired quality of the treated water.

Nevertheless, besides the effectiveness of the treatment, it must be taken into account the fact that there are technologies that are considered to be more environmentally friendly than others. Then, some cause less impact on the environment like: the use of fewer quantities of treating substances, or the use of biodegradable treating substances, or use of technology that require less energy, among others.

Therefore, the set of elements of evaluation that form the sector of analysis **6. Waste Treatment overview** from the Hazardous Substances management group (see Figure 5.2) are:

6.1 Water discharge limits compliance
6.2 Extension of HS-waste treated in the company
6.3 Process potential environmental impact

5.2.2.4 After Treatment - Final dangerous waste.

Hazardous waste (HW) management is the final step on this proposed evaluation method. There are legal requirements to fulfil in this matter, in order to reduce the risk that final generated waste represents to workers and environment.

However, there are no legal indications on reducing waste over time or reduce waste hazard level; this would be part of the company's EMS and, if it follows one of the mentioned international guidelines, also part the continuous improvement objectives.

This section includes three different sectors to consider on final waste management: the final waste characteristics, temporal storage site and final destination responsibility.

7. HS as final company's generated waste

In this seventh sector part of the Hazardous Substances management group (see Figure 5.2), the elements to analyze shall describe first of all the danger waste represent, and if the company is aware of it. This is, in many times, a legal requirement and needs to be proved with reported analysis by certified laboratories.

Then, the concept of continuous improvement would be analyzed by checking how change the elements of HW generation, atmospheric emissions and hazard levels on waste according to time and regardless of the productivity increase in the plant's activities, since clearly higher levels of on production would lead to higher levels of waste generation, and the other way around.

The set of chosen elements of evaluation that would bring up this information are:

7.1 Hazard level of final waste collected
7.2 Waste generation vs. production ratio over time

7.3 Emissions generation vs. production ratio over time
7.4 Hazard level of generated waste over time

8. Occupational Health and Safety – Hazardous Waste Storage

This eight sector part of the Hazardous Substances management group (see Figure 5.2), evaluates most of all the actual status of the temporal storage conditions. This is also a regulated element in many countries, resulting on similar aspects to consider in comparison with the Storage sites for chemical substances.

However, they only establish general requirements, while on the other hand, the MSDS are more specific on how to manage the resulted waste from the substances used (e.g., how to identify waste, packing disposal). These notes have to be taken into account if is desired a responsible management of such waste.

Additionally, it is important to consider the time that containers can remain in these temporal storage warehouses, since hazardous waste represents a considerable risk for both, environment and workers. Moreover, in some countries, authorities have established limits on storage times and therefore, the companies have to send hazardous waste out from the plant's waste warehouse before this limit of time has expired.

Therefore, the elements to be considered in this case are:
8.1 Planning and registry control on the storage of HW
8.2 HW containers status
8.3 Safety site measures in the storage of HW
8.4 Adequate and safe HW temporal storage time and maintenance

9. HS Final Destination – Knowledge and verification level

Company's responsibility on waste management does not end by sending the hazardous waste away from the plant. This is also noticed by the authorities and at the moment in some countries is required to keep some specific records on this matter, like consignment notes proving transportation and the delivery of this hazardous waste to designated places, further waste management or treatment and final disposal of hazardous waste.

Also, authorized permissions are required by law from the intermediate companies in charge of storage, as well from the company that eliminates or confine this hazardous waste.

Additionally, companies can go further these requirements in order to practice a responsible management of hazardous waste by gathering and verifying information like knowledge and of the following stages that the waste passes through after been collected, as well as the revision of the vehicle's conditions that transports this waste.

Finally, the choice among different final treatment services (e.g., incineration, chemical treatment, and deactivation) would reveal different environmental tendencies of the company, since environmental behaviour cannot have the same rate from a company that chooses an incineration treatment, to the one that chooses deactivation.

On the same way, by evaluating final confinement of hazardous waste that cannot be treated, it is checked if the generator has knowledge about the final location of its waste and the characteristics of such place (e.g., safety of the confinement procedures, location that do not endanger communities' safety, among others). This can be done by revision of documents and records that prove the final ending of such hazardous waste.

Then, the mentioned information is resumed in the following elements of evaluation in the sector of analysis **9. HS Final Destination – Knowledge and verification level** from the Hazardous Substances management group (see Figure 5.2):

9.1 Knowledge of the following treatments of the sent waste
9.2 Hazardous waste safe transportation
9.3 Waste treatment previous confinement
9.4 Waste final destination location

5.2.3 About the specification of the elements.

Regarding the set of elements included in each sector of evaluation, it has to be mentioned that the compliance of the evaluated company with some of them obligatory according to the corresponding legal framework of the company's location. However, for this proposed method, the mentioned elements have been chosen as a representative examples of what can be taken into account for the evaluation.

Nonetheless, it is possible to adapt such sectors of evaluation in order to better fit the company's needs, and direct the evaluation to verify the compliance with the particular regulations of the country in which the company is located. This would result in a more detailed evaluation, in which the proposed checklists have to be also adapted, adding more specific elements of revision that meet legal needs in the different fields that the HS management involve.

However, it is important to consider that the adaptation of each element of evaluation to the specific regulatory framework of the country involves a deeper research and adaptation process, which is out of the reach of the present study and therefore, was not applied for obtaining the final results in the analyzed study cases.

On the other hand, in this section it is shown how this adaptation can be done in order to specify which elements have to be taken into account when legal norms are included in the proposed evaluation. In order to do this, it would be necessary:

(1) A preliminary search of the applicable norms in the country, and in some cases the ones for specific regions, according to the process(es) and to the type of hazardous substances involved in them.
(2) The extraction of the elements of evaluation from these norms.
(3) The inclusion of the selected elements in the corresponding developed checklists *(see section 5.4.1)*.[9]

To exemplify this, here is shown how to adapt element ***8.3 Safety site measures in the storage of HW*** from the sector **8. Occupational Health and Safety - Hazardous Waste storage** *(in section 5.2.4),* in order to meet legal requirements according to the Mexican regulatory legal framework.

In the specific Mexican case of study in this research (TK-SLP), the applicable specific regulations to the processes held in the industrial plant described Chapter IV *(see sections 4.2 and 4.4),* according to the national regulatory framework are *(also mentioned see Chapter II, section 4.2.3.3)*:

1. General Law for Waste Prevention and Comprehensive Management, LGPGIR
2. NOM-005-STPS-1998. Relative to health and safety conditions in the workplace for the handling, transport and storage of hazardous chemicals. D.O.F. 2-II-1999.

[9] *The checklists proposed and described in section 5.4.1 do not include the adaptation to the specific regulatory framework explained in this section 5.2.3*

3. NOM-006-STPS-2000. Materials handling and storage - Terms and safety procedures. D.O.F. 9-III-2001.
4. NOM-010-STPS-1999. Health and safety conditions in workplaces where are handled, transported, processed or stored chemicals that can cause pollution in the working environment. D.O.F. 13-III-2000. (Elucidation and errata DOF 21-VIII-2000).
5. NOM-017-STPS-2008. Personal Protective Equipment (PPE) - Selection, use and management in the workplace. D.O.F. 9-XII-2008.
6. NOM-018-STPS-2000. System for identification and communication of hazards and risks posed by hazardous chemicals in the workplace. D.O.F. 27-X-2000. (Elucidation D.O.F. 2-I-2001).
7. NOM-025-STPS-2008. Lighting conditions in the workplace. D.O.F. 20-XII-2008.
8. NOM-026-STPS-2008. Colours and health and safety signs and identification of risks taken by fluids in pipes. D.O.F. 25-XI-2008.
9. NOM-028-STPS-2005. Labour Organization, Process Safety of chemicals. D.O.F. 14-I-2005.

After the revision of these listed norms, the evaluator has to verify the compliance of all applicable requirements; therefore, add them to the ones set on the corresponding checklists of this methodology, in order to accurately evaluate the company's environmental performance in this element of evaluation. The aspects to check after the adaptation of the specific element of evaluation ***8.3 Safety site measures in the storage of HW*** to the case of study in TK-SLP would be the following:

1. Containers segregation
2. Location outside the production plant
3. Fireproof walls
4. Safety drain
5. Containment pit (no connection to drain)
6. Illumination between 50 and 100 lux
7. Free access and transit
8. Danger signalization
9. Fire extinguisher
10. If the waste storage place is in a *closed area:*
    a. Ventilation
    b. Outside protection
    c. Capacity not overpasses
11. If the waste storage place is in a *open area:*
    a. Site height $\geq$1.5 time max. flood level
    b. Flat and waterproof floor
    c. Waterproof cover (if there is no ceiling)

5.3 SET OF DIFFERENT ENVIRONMENTAL BEHAVIOUR GROUPS.

The proposed EMS evaluation methodology takes into consideration four possible kinds of "environmental behaviour". This concept refers to the different conducts that an industrial company would present when each of the corresponding elements of evaluation relating management of hazardous substances (HS) is revised.

The differences among such behaviours relay on: the awareness on the company's environmental impact and willingness on minimizing it; the kind of compliance with environmental issues relating HS management that the company pursuits (e.g., legal or self-established); organizations skills on implementing, managing and maintaining its EMS; and the special considerations the company held on hazardous substances management. In the following sections are general and resumed characteristics of each of these environmental behaviours.

However, it is important to remark that the same company can present different conducts on different elements of evaluation, resulting that its actual environmental behaviour is a mixture of two or more. Then, the evaluator must at the end integrate those conducts and shape an individual description for the company that is been studied.

Additionally, in mixed-behaviour situations, the comparison of such results with the company's environmental scope and objectives would help the evaluator to detect possible opportunity areas that need to be improved.

5.3.1 Environmentally inadequate.

The case of "environmentally inadequate" behaviour, or *Level D*, corresponds to what can be described as *the worst case* on environmental responsibility. This means that the company presents the lower level of consciousness on the consideration of the corresponding element of evaluation.

Referring to the environmental element of evaluation itself, this type of behaviour would denote the lowest environmental care situation. This can be caused by different reasons, from lack of knowledge on the relevance of the element or low relevance among the company's priorities, to an unrevised non-compliance part of a functional EMS in process of improvement.

For this reason, the interpretation of the obtained results must be done in the context of the results of the whole sector, its relevance in the group and relation with the EMS scope of the company. This is with the purpose of avoiding misinterpretations.

Then, if the company from which EMS of hazardous substances has been studied is at the end classified in this category, it would indicate: (1) a non-organized EMS or the insufficient inclusion of HS management elements into the existing one; (2) the company would present less control (or

not at all) over the environmental impact of the processes that uses these substances may cause; and (3) probably less capacity to detect legal breaches or internal non-compliances on.

Yet, there may exist some environmental care elements in the company's management, but they would probably not be related to HS management, or not fully met authority's requirements, in order to avoid fees due to environmental or workers health damage.

5.3.2 Environmental legally accepted.

In the *Environmental legally accepted behaviour* or *Level C*, companies are aware on their environmental responsibility due to the pursuit on compliance with legal requirements which, as in the previous case, has as main motivation the prevention of environmental fees or workers accidents (which also means costs and economic looses).

Meeting legal requirements includes not only the ones already established in the international, national and local applicable legislation, but also the ones that the organization itself established in official documents, like the Manifest of the previous Environmental Impact Assessment.

In this methodology, at the element evaluation level, this classification would represent that the company is aware on the applicable environmental legislation on HS management; then, seek to remain below established pollution limits (e.g., water hazard pollutants, green gases emissions); or adopt the established work safety measures (e.g., safety equipment, danger signalization, fire extinguishers) in the process(es) that involve HS, in order to prevent accidents; among other requirements that are legally bounded with HS management in the corresponding country.

However, not all the elements of evaluation listed in this proposed methodology are included in legal statements (e.g. documented EMS, environmental policy); this fact makes them non-applicable under legal framework, and for this reason are not revised by the authorities, leaving gaps in the description of the actual environmental responsibility.

Then, as the general company behaviour level, this means that the company probably looks up for keeping records of regulated activities that involve HS, acquiring environmental permissions to manage them and establishing their own sort of system that organize these elements, but not necessarily manage a documented EMS or documented procedures that indicate proper management of HS. This is a general and common case for companies that do not seek for international market, and therefore don't pursuit certification of their EMS.

Additionally, it is worth mentioning that as long as legal environmental requirements are fulfilled, the company should not have any problems or fees on environmental issues, but this would last until the law changes or someone gets affected by an unregulated issue. This makes the company vulnerable to changes and forces the company to spend time for adaptation and continuous investments in the implementation of the corrective actions required.

However, from an environmental and sustainable point of view, this kind of behaviour is not considered as the best to adopt, since the decisions to be taken under this concept would not assure a safe and healthy environment or improvements on minimizing environmental impact.

5.3.3 Environmentally Active.

The case of *Environmentally Active behaviour* or *Level B*, refers to companies that count with an EMS that has been developed, organized, implemented, frequently revised and maintained. In this context, the company establishes a commitment, with the authorities and the public, on environmental responsibility.

To facilitate this, companies can make use of international guidelines (e.g., EMAS, ISO 14001), within they manage to: create a document that states its environmental commitment; demonstrate legal environmental compliance; and receive a certification by an authorized third-party company that would be internationally acknowledged.

Since there are differences in the requirements among different international guidelines, and moreover there are also differences on the way companies adapt its EMS to these requirements, it cannot be established in this proposed methodology that, a company that counts with a certificated EMS, automatically falls into this classification. In the same way, it can be the possibility that a company falls into this classification, without a certified EMS.

Therefore, at the element's evaluation scale and as a general description, this classification may indicate that the company either: (a) fully complies with that legal requirement, (b) complies with the documented procedures required by the adopted guideline, or (c) complies with what has stated itself as targets and objectives in its EMS.

Then, at the company's behaviour scale, what defines the company as "environmentally active" is the actual inclusion of the following elements (common among the most popular guidelines):

- the set of an environmental scope,
- the identification of the applicable environmental impacts, and
- continuous improvement.

Being the first and second requirements specifically oriented on environmental impact awareness, the company management is committed to fulfil the legal and other requirements on this matter. Until this point, the company acts as described in the "environmental legally accepted behaviour", complying with what has been established and required by law.

However, the third element is what would mark the difference, since the commitment of continuous improvement pushes the company to have a structured and organized EMS that facilitates its revision and identification of possible breaches. Nevertheless, most of the actions

would be more focused on corrective, rather than preventive, measures in order to remediate detected breaches.

Finally, it is worth mentioning that not all cases of companies with certificated EMSs are actually consistently functioning over time. That is why elements shall be evaluated and after that designate an environmental behaviour classification.

5.3.4 Environmentally Proactive.

This is the fourth type, *Level A or Environmentally Proactive behaviour*, on environmental management. An "environmentally proactive" behaviour implies the inclusion of steps further than what has been already established by law on environmental responsibility.

Is in this case where awareness on the actions that induces significant environmental impact does not only imply the detection of non-compliances to correct them, but also the identification of opportunity areas to either prevent potential damage, or improve the processes performance in order to obtain actual environmental improvement.

At the elements of evaluation scale, this category would be assigned when the evaluated company grade fits the best hypothetical response from an environmental responsible point of view. Additionally, it is important to point out that the hypothetical descriptions that are found in this category were planted taking into account some elements of the concepts of: sustainability, environmental care, the precautionary principle and continuous improvement.

In the context of the evaluation proposed in this study, for a company's EMS on Hazardous Substances can be classified as "environmentally proactive", if most of the evaluated elements fit under this classification.

These companies count with established EMS, which are consistent and frequently revised in order to maintain its functionality. They have already demonstrated fulfilment of legal and established requirements in a satisfactory manner.

A company in such situation and, with a continuous improvement goal to maintain, is able to build up its own standards that may go further than the already fulfilled and orient them to a more effective environmental performance improvement on the company's practices.

For example, as matter of HS management, it would seek for improving research on other kind of chemicals that would substitute dangerous input products; or investments on technology that reduce risk exposure and/or waste generation quantities, among other possible improvements.

Additionally, the company should adopt concepts on sustainability and precautionary principles in the managing of its activities, by taking into account social concern and workers involvement on

the decision making process, which can be noticed for example by implementing programs to enhance participation from workers, in order to contribute to improvements into the process(es) that involve HS; or promote social awareness on environmental matters, as by promoting improvement programs of neighbouring areas (e.g., development of green and recreational areas); then as matter of HS management, promotion of dangerous waste identification, separation and proper disposal (e.g., car oil, oil containers, aerosol empty cans).

Finally, it is worth considering that, though it is difficult to reach the classification into this category as the overall company's behaviour, it is not impossible if the company counts with an established, organized and functional EMS on HS management, since it is supposed to be the next step in the context of continuous improvement and environmental care, once legal requirements have been fully complied.

5.4 EVALUATOR'S CONSIDERATIONS FOR RESULTS INTERPRETATION.

The preceding proposed methodology has been described with the main purpose of improving environmental performance on hazardous substances management in the industry, by identifying opportunity areas in which the company may improve its procedures in order to minimize environmental impact and increase occupational safety efficiency.

Then, for the application of this methodology it has been considered that the information must be collected in a conscious way, and as in other evaluation auditing methods, its reliability depends much on the evaluator's skills on information gathering, personal perspective and analysis integration

However, it is worth mentioning that since this is a qualitative method, it cannot be ignored the influence of the evaluator's bias through the evaluation and categorization step of the included elements as well as in the final results integration and interpretation.

Therefore, considering the existence of different environmental personal approaches, the final result would also include the evaluator's own opinions and beliefs on what needs to be improved and how to do it as matter of hazardous substances management in the industry. On the other hand, this is not necessarily a negative aspect of the method and can be managed in a constructive way, taking advantage on the expertise and professional knowledge of the evaluator.

Furthermore, to apply this method it is recommended that the evaluator has a supporting standpoint on the adoption of the precautionary principle in the industry practices, understanding on the importance of environmental responsibility and wide risk perception involved in the hazardous substances management.

5.5 APPLICATION STRATEGY AND INFORMATION GATHERING FORMATS.

According to the previous information, that described the evaluation organization and the different possible classification of the company's EMS of hazardous substances performance, it can be considered that this proposed methodology is qualitative descriptive. It does not grade performance using averages or statistical numerical data; it classifies the company's performance on the different listed evaluation elements, and more specifically, focuses in the way that the company manages its hazardous substances.

Therefore, for the application of the proposed methodology it has been considered three stages, which the evaluator has the responsibility to conduct in an efficient way, providing true and verifiable information. However, the evaluator's characteristics and reliability on the gathered information is described in section 5.5.

5.5.1 Information gathering and begin of evaluation stage.

The first stage is the Information gathering process, which has the purpose of describing the EMS organization in the company and, most important of all, the understating of the process(es) in which HS are being used.

To facilitate this, the evaluator can make use of the corresponding forms developed specifically to the evaluation of an EMS of hazardous substances in an industrial company. Each question or element to evaluate is directly related with one of the elements of evaluation described in the previous sections. However, in order to apply those formats some fieldwork activities are included (Figure 5.3) which can be explained in the two steps detailed in the following sections.

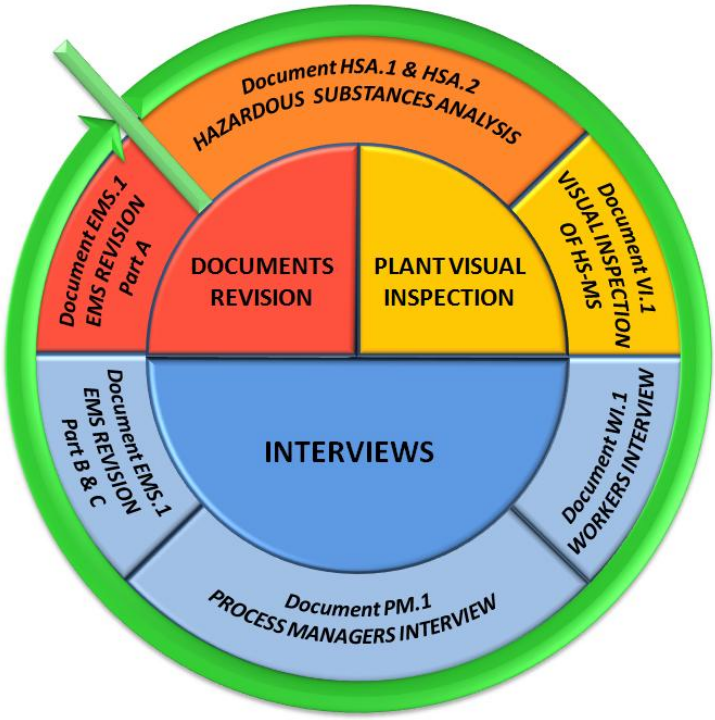


Figure 5.3 *Activities involved and corresponding forms to fill in the information gathering stage.*

STEP 1. HAZARDOUS SUBSTANCES ANALYSIS

As can be noticed in Figure 5.3, the corresponding formats to the Hazardous Substances Analysis (Documents HSA.1 & HSA.2, Appendix A.1 and A.2, respectively) are signed as the first step of the information gathering stage in this method; it includes activities like plant visual inspections and documents revision.

First, the analysis recommends the *Process(es) description* (through the plant's inspection), with the main purpose of identifying inputs and outputs of all chemical substances used in the process(es) of study *(mentioned in Chapter IV, section 4.2)*. The diagram(s) detailing this information shall be included in ***Document HSA.1***.

Then, ***Document HSA.2*** should be used to resume information from *Safety Data Sheets (SDS) or Material Safety Data Sheets (MSDS)* from all the substances involved in the process(es), in order to extract hazard properties and determine whether they are relevant to consider as HS in the study or not.

Once relevant HS have been identified, it is possible to proceed with the rest of the activities involved in the method. The suggested sequence is also shown with an arrow on Figure 5.3.

STEP 2: CHECKLISTS FILLING

After the HS identification, the information shall be gathered from different sectors of study (see Figure 5.2) and has to be collected through the use of other four developed checklists described on Table 5.1.

These checklists were elaborated by integrating the information on Chapters II and III of this study, including then: EMS requirements according to the ISO 14001and EMAS guidelines; national and international norms on HS management; different authors' opinions on the HS management and EMS performance; and my personal perception in the topic. However, the proposed documents should be adapted and adjusted, in order to fit company's needs in other cases of application.

Table 5.5 *Checklists to be used in the Step 2 of the information gathering stage.*[10]

CHECKLIST NAME		DESCRIPTION	SECTORS INCLUDED
Document VI.1 VISUAL INSPECTION OF HAZARDOUS SUBSTANCES MANAGEMENT STAGES (HS-MS)		Information gathered from the observation and notes during the plant inspection(s). Describes the physical aspects to take into account during the different stages of: storage, use, waste treatment and waste storage of the HS.	3. Workers involvement 4. Occupational Health and Safety Storage and Use of HS substances 5. HS as input materials 6. Waste Treatment Overview 8. Occupational Health and Safety Hazardous Waste storage
Document WI.1 WORKERS INTERVIEW		Guideline for the interviews with the line workers (those that handle HS) and understand their danger perception and involvement in the company's EMS.	3. Workers involvement
Document PM.1 PROCESS MANAGERS INTERVIEW		Guideline for the interviews with the line process(es) manager(s); collects specific information about HS and other data about the process(es) management and relation with EMS objectives and continuous improvement goals.	5. HS as input materials 6. Waste Treatment Overview 7. HS as final company's generated waste 8. Occupational Health and Safety Hazardous Waste storage 9. HS Final Destiny - Knowledge and verification level
Document EMS.1 EMS REVISION	***Part A***	Revision of elements of evaluation that describes the EMS structure and organization. It includes the revision of the corresponding EMS's documents.	1. Company's EMS bases and principles
	Part B	First part of the interview's guideline with the EMS responsible(s); It describes managers perception on EMS structure and its relation with HS management in the process(es).	1. Company's Environmental Management System principles and characteristics 5. HS as input materials
	Part C	Second part of the interview's guideline with EMS responsible(s); it looks forward to identify head managers' professional characteristics that may	2. Head Managers

The filling of the corresponding documents includes also the classification of the obtained response (or result), taking as base the hypothetical possible answers shown for each question/element of evaluation. Figure 5.4 shows an example of how the question on each form is directly related with its corresponding element of evaluation *(described in each sector in Figure 5.2)* through an "Evaluation code"; then, when different answers for different HS are considered, resulted values (or grades) are also separated by individual blocks for each HS.

[10] *The listed documents can be found in Annexes X to X respectively.*

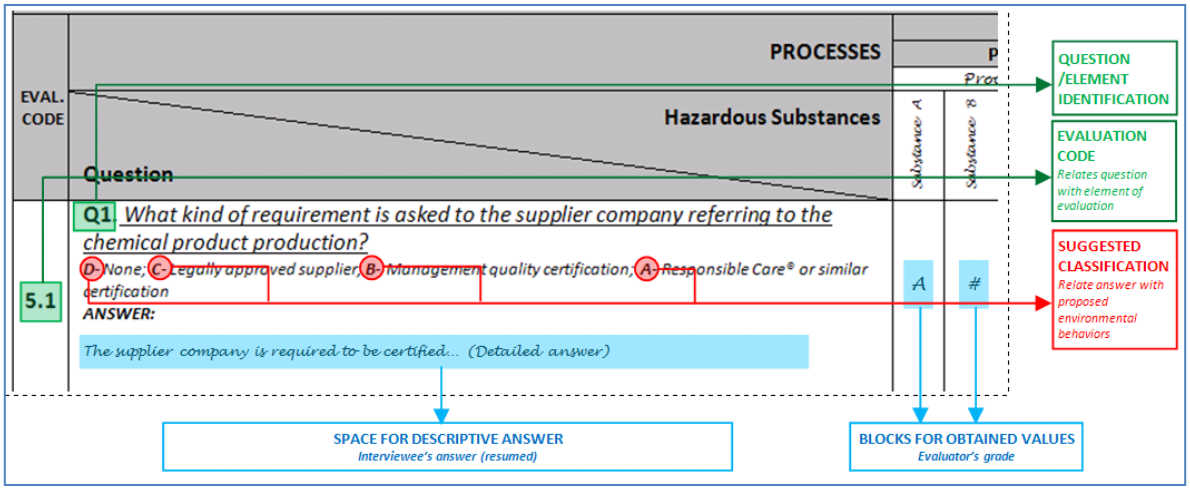


Figure 5.4 *Checklist's example with filling procedure and sections description.*

Then, the corresponding activities involved in the STEP 2 of the information gathering stage are described in the following sections.

a. ***<u>Plant visual inspection:</u>***

To indicate conditions relating the already identified HS along the different stages of: storage, use, treatment and waste storage. In this case, are taken into account: site, machinery and substance containers conditions and observed safety measures (e.g., use of personal protection equipment, hazard and emergency signalization). The information is gathered in the corresponding spaces in ***Document VI.1*** *(Appendix A.3).*

b. ***<u>Documents revision:</u>***

i. *Environmental Management System related documents:* regarding information that describes the way in which the company manages environmental related issues (e.g., environmental policy, targets and objectives, commitment). It includes the revision of the Environmental Handbook (if exists). Elements of revision are included in ***Document EMS.1. Part A*** *(Appendix A.4).*

ii. *Analysis reports:* from internal control (e.g., wastewater treatment, fine particles in air, waste analysis indicating hazard properties). Information can be used as complementary evidence for information in ***Document VI.1*** and ***Document PM.1*** *(Appendix A.5).*

c. ***<u>Interviews:</u>***

i. *Workers in the process(es) line:* with the purpose of knowing where and how they use HS; in the same way, it is included information about HS and environmental impact awareness, emergency training programs, the workers' involvement in the decision making process of the company's environment related issues, and improvement of safety and environmental procedures. Information is gathered in ***Document WI.1*** *(Appendix A.6).* Additionally, the number of repetitions on the application of the

interview depends on the number of in-line workers involved. However, it is always recommendable to apply it more than once using planned sampling methods, in order to compare some answers and corroborate the factual information and at the same time support the reliability of the results that depend on the accuracy of such answers.

ii. *Process(es) manager(s):* with in line-process(es) supervisor(s), which are the ones that can verify information in ***Document VI.1***; however, this interview is focused on the research and introduction of different input materials and technologies, waste transportation and final disposal concern. This interview should follow elements indicated in ***Document PM.1***, and as before, include only considered relevant comments in the corresponding designated space.

iii. *EMS related:* with the manager(s) in charge of the environmental matters in the company, and, if the case of existence of a structured EMS, the manager in charge of its surveillance, revision and functioning. The interview should follow elements included in ***Document EMS.1 Part B*** and ***C*** *(Appendix A.4);* however, additional comments should also be included in the corresponding "Comments" sections of the same document, as long as they are considered relevant for the evaluation.

5.5.2 Analysis of the obtained results.

After having filled all checklists, the following stage is the analysis of the obtained results. As general description, this refers to do a comparative analysis between the answer's obtained categories with the corresponding element of revision in the ***Matrix of environmental behaviours on elements of revision*** *(Appendix A.8),* and would be done as described in the following steps.

It is worth mentioning that this stage involves mainly a reflective process from the evaluator's side, and the outcomes are mainly reports and resumes of the description of the sectors of evaluation, except for the identification of opportunity areas in which a specific document is proposed.

STEP 1: CATEGORIZING ELEMENTS

The analysis begins with the first sector on the list in the matrix *(Company's EMS. Bases and Principles)*. It starts by categorizing the obtained grade of the first element of revision into one of the described environmental behaviours, according to the answer given on the corresponding element of evaluation in the checklists on Table 5.1. Then, the same is done moving down with the rest of the elements of evaluation in the corresponding sector. This step is repeated in the same way for the categorization of all elements in all sectors, applying the following considerations:

a. In order to identify which element of evaluation matches which question or element in the checklists, the evaluator can make use of the *Evaluation code* and the *Question/Element*

Identification columns. Both are referencing numbers to facilitate finding information in the corresponding documents, and can be identified next to each question or element in each checklist as shown on previous Figure 5.4.

b. Some elements of evaluation may correspond to more than one question or element to evaluate in the mentioned checklists. In these cases the four descriptions of the possible environmental behaviours have already integrated the different evaluated aspects, and as in the other cases, the evaluator should categorize the real obtained result taking such descriptions as a base. After that, corresponding additional comments shall be taken into account to complement the sector description.

c. In the case that the actual element's results do not fit the best into any of the presented descriptions, or stay in the middle of different descriptions, these should be included also as additional comments. Additionally, the evaluator has the possibility to complement such descriptions in order to better differentiate them and at the same time improve the propose matrix.

STEP 2: SECTORS DESCRIPTIONS

After having categorized all the elements in the same sector, the sector is also categorized and independently described according to the obtained results. This shall also include the additional comments done from the analysis of the elements of evaluation.

In this step, the evaluator has to integrate the different results obtained in the previous step into a resumed description of the sector. On the other hand, it is important to remember that in the same sector of evaluation, the obtained categories among elements of evaluation can be different, resulting on a sector with a mixture of environmental behaviours. In these cases, the accuracy of the results interpretation, sector description and categorization relays on the evaluator's ability to integrate the information.

Moreover, since this method is mainly qualitative and does not uses weights to differentiate between elements significance in each sector, the evaluator has to develop a reflective analysis in order to decide whether all elements have the same importance on the description of the whole sector, or weight them in a different way, giving higher values to the ones tht represent more significance in the sector.

STEP 3: OPPORTUNITY AREAS IDENTIFICATION

The STEP 3: OPPORTUNITY AREAS IDENTIFICATION, is highly dependent on what the company states its environmental priorities, which can be extracted by the information provided on the first sector of evaluation "*Company's EMS. Bases and Principles*".

Therefore, in the description of the sectors of evaluation 2 to 9 is important to consider the information provided in the first sector of evaluation, since the orientation of the company's EMS is described here; then, the following sectors would probably be oriented on the same direction,

and the comparison with the information provided in this first sector would help to identify opportunity areas of improvement.

In order to do this, in this proposed method is suggested that the evaluator make use of ***Document ROA.1*** *(Results and Opportunity Areas, Appendix A.7).*in which concentrates results of the evaluation in a practical way that would help the evaluator to identify opportunity areas. This document includes also a blank table in which the evaluator shall introduce the element's evaluation code (which serves as identification) and the resulted environmental behaviour (EB OBTAINED). Additionally, the evaluator must include some comments for each opportunity area identified (e.g., how to reach this category, why was this considered as an opportunity area).

5.5.3 Final report. Results and opportunity areas.

The final stage of this proposed method is the integration of the obtained results into a comprehensive report for the company's head managers. In this report the main sections should be:

a. an overall description of the company's EMS of hazardous substances, categorizing the company in one of the four proposed environmental behaviours, and
b. a list of recommendations that lead to the improvement of the elements that do not reach the desired environmental behaviour.
c. a description of the benefits that such recommendations would bring to the organization (e.g., prevention of legal breaches, costs saving from materials use and waste generation reduction, better marketing opportunities when reaching international recognition on environmental proactive performance).

These documents have to be result from the integration of experiences and comparison of environmental goals and actual performance of the company on HS management.

However, the evaluator should take into account the possible case in which the company's priorities are not directed to environmental performance improvement, and that could difficult the introduction of changes in its EMS. In such cases, it is recommended that the evaluator do not let aside that the main purpose of analyzing such systems is to improve them, and for this reason do not hesitate to include recommendations that stand for a better environmental management of hazardous substances; additionally, the evaluator should emphasize that such recommendations would probably be reflected in aspect that the company may not be aware of, such as: less vulnerability to changes on environmental legal requirements, more efficiency on occupational safety procedures and most important, reduction of environmental impact.

CHAPTER VI.

EMS OF HAZARDOUS SUBSTANCES EVALUATION. RESULTS AND INTERPRETATION

The proposed evaluation tool described in Chapter V was applied in order to categorize the environmental performance of the Environmental Management Systems (EMS) of hazardous substances (HS) of two plants of a German-Mexican industrial company, whose descriptions were presented in the study cases of Chapter IV.

This chapter presents the particular results from its application in both cases of study, as well as the conclusions obtained from each analysis, which includes the overall categorization of the company's EMS of HS, the results from each sector environmental performance and the identified opportunity areas in each case.

The evaluation was done in the same period of time of the fieldwork research signalized in the description of both study cases. However, it is important to remark that special considerations were taken for the information gathering and analysis in the case of TK-Hagen, due to presented difficulties during the fieldwork research *(see section 6.1)*.

It is worth mentioning that it is not an objective of this research to display particularities on requirements compliance or possible legal breaches in the company's EMS of HS, but to make an overall description of the functioning and environmental performance of such system. Therefore, this section summarizes the evaluation results up to sectors environmental performance.

The evaluation exercises of two industrial plants of the same company made possible the comparison between the environmental performances of both Environmental Management Systems (EMS) of hazardous substances (HS). In this last part are detected some aspects on both plant's management that could be improved by motivating the crossing information between both plants on particular subjects.

Finally, the differences between application experiences of the evaluation tool in the two study cases, mentioning adaptability of the proposed method are discussed. Additionally, recommendations to be considered in the further applications of the proposed tool are also included, in order to make it able to bring more accurate and practical results.

6.1 EMS OF HAZARDOUS SUBSTANCES. INDUSTRIAL PLANT IN HAGEN-HOHENLIMBURG, GERMANY.

The presented results were obtained from integration and analysis of the information gathered during the fieldwork research carried out on December 2009, as described in the German study case in Chapter IV *(see section 4.3)*.

However, in this particular case some difficulties were presented during the completing of the information gathering stage, which obstructed the execution of supplementary plant visits (specifically the visual check up of storage sites for input materials and hazardous waste), personal interviews and additional documents revision, and therefore the appropriate filling of the corresponding checklists.

Nevertheless, despite these difficulties, it was considered possible to carry out the application of the evaluation tool for the EMS of HS in TK-Hagen, since the information gathered during the fieldwork research allowed the analysis of 30 elements of evaluation (60% of the total evaluated elements). On the other hand, for the categorization of the other elements of evaluation was considered appropriate to assume an “expected” environmental response, by interpreting the EMS’s environmental policy description, the expected organizational structure established as requirement in the ISO 14001 certification, and some related comments taken from the informal interviews carried out on the already mentioned fieldwork research. Figure 6.1 shows the different recurrence of the assumptions made for the “expected environmental behaviours” by sector of evaluation.

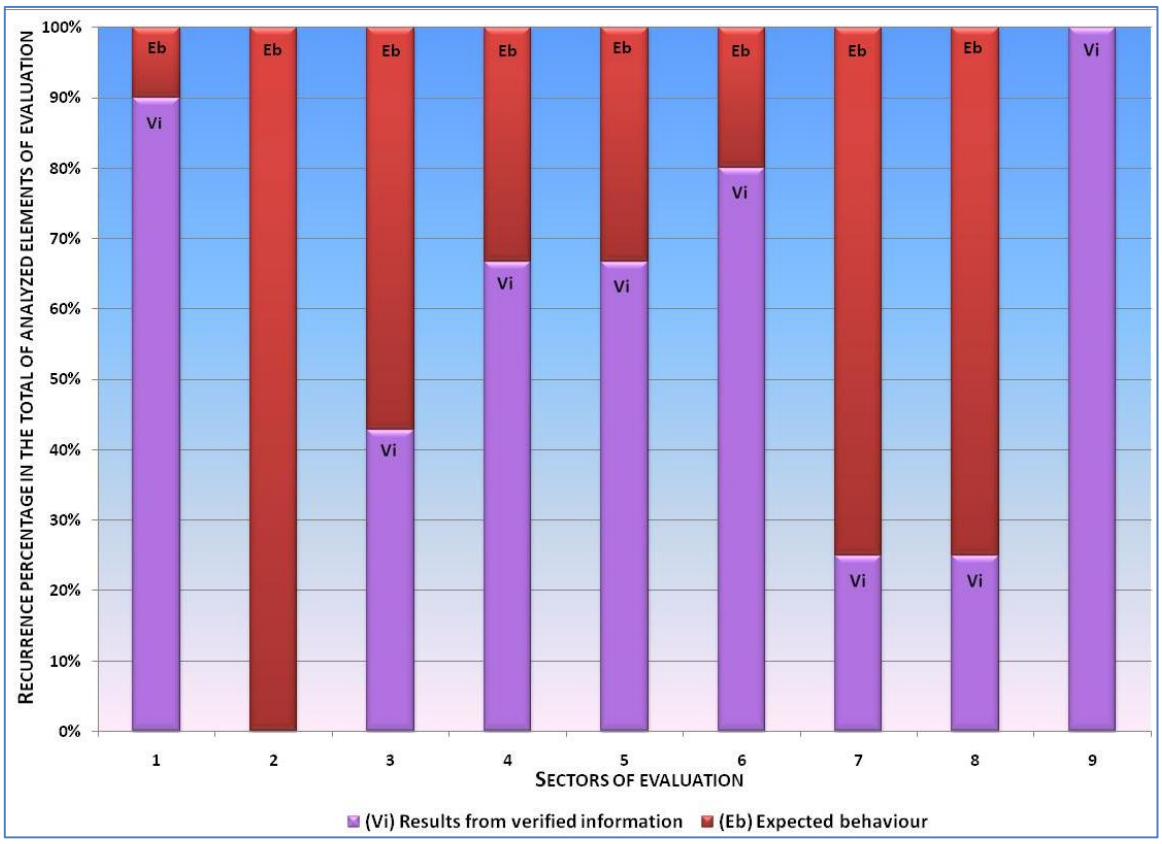


Figure 6.1 *Ratio of expected environmental behaviour to verified information on TK-Hagen sector's results. Sectors of evaluation in the graphic:* ***1.*** *Company's Environmental Management System principles and characteristics;* ***2.*** *Head managers;* ***3.*** *Workers involvement;* ***4.*** *Occupational Health and Safety - Storage and Use of HS;* ***5.*** *HS as input materials;* ***6.*** *HS Waste Treatment;* ***7.*** *HS as final company's generated waste;* ***8.*** *Occupational Health and Safety - Hazardous Waste storage;* ***9.*** *HS Final Destination – Knowledge and verification level.*

Taking this into account, results are resumed in Figure 6.2. This chart presents that the company's HS management is described with a primarily environmentally active behaviour *(B, 68%)* mainly supported on environmental management and occupational safety international guidelines (i.e., ISO 14001 and OHSAS 18001); then, in a second place TK-Hagen presents an environmental proactive behaviour *(A, 18%)* marked by the recognition of sustainability and precaution orientation; and finally, the presence of elements that at the moment just reach the level of environmental legally accepted performance *(C, 16%)*.

Therefore, it can be said that at the moment the environmental performance of all company's actions relating HS management meet current German legal requirements; then, the majority have been upgraded and yet oriented to maintain compliance with the standard ISO 14001, which in this case is noticeable mostly by the presence of some elements like: the organizational structure, the documents and operational control, emergency preparedness and internal audits that revise the functioning of the system.

Furthermore, it is also observed that some elements point to a proactive environmental behaviour, which in the case of TK-Hagen is identified in sectors 3 and 5 (***Workers Involvement***

and ***HS as input materials***, respectively). From this it can be said that the company has a particular interest on workers involvement by promoting, as stated on the company's environmental policy, the communication between labour and top management levels in order to gather ideas that could lead to the continuous improvement of the processes.

On the other hand, TK-Hagen marks an interest on having better management of HS as input materials, since at the moment promotes research on the replacement of some of these chemicals and have revealed the probable inclusion of less hazard pH buffers in the process. Moreover, according to the information provided by the coating process's supervisor, the paint's dust recovering procedure is very effective and, in contrast with what has been described in TK-SLP there is no waste generation in this stage of the process *(section 4.2.2).* However, this information could not be verified through visit on the waste storage site of the plant.

Nevertheless, these two facts mark an environmental proactive orientation of the activities' performance in this sector.

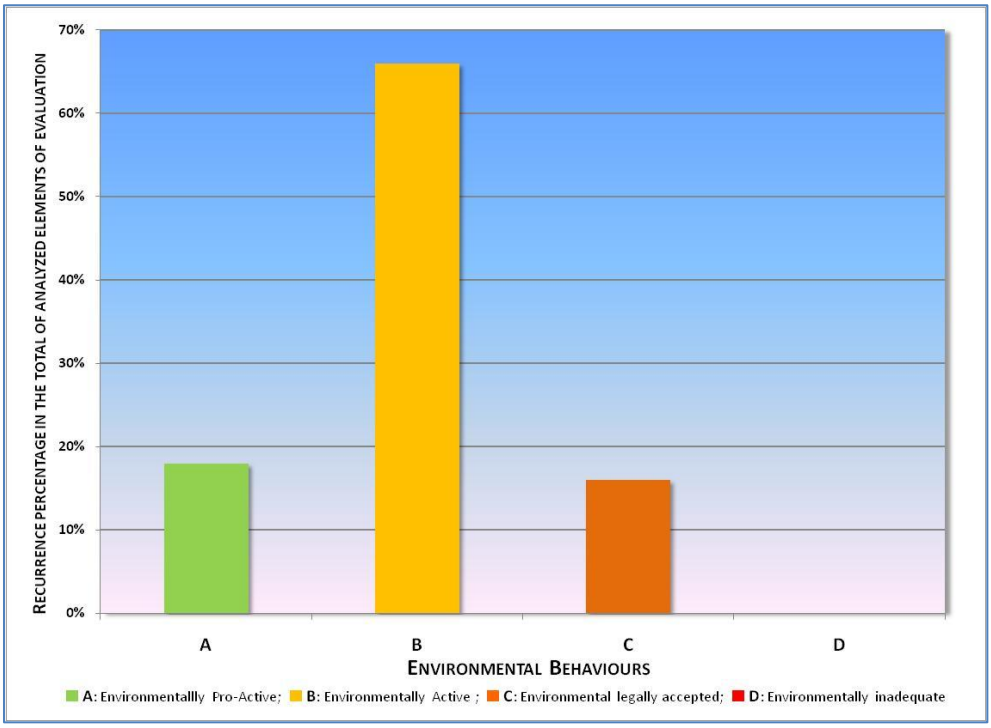


Figure 6.2 *Results graphic from elements categorization in TK-Hagen.*

The following sections include the description of the environmental performance by each of the analyzed sectors according to the proposed evaluation tool in this study research. Then, taking these results into account, a resume of the identified strengths and opportunity areas in the HS management in TK-Hagen is presented, finishing then with an integrating conclusion of the plant's environmental performance regarding HS management.

6.1.1 Environmental behaviour by sectors of evaluation.

In order to have a better understanding of TK-Hagen's HS management, it is necessary to have a particular description of each evaluated sector. Therefore, Figure 6.2 integrates the resulted categories of all analyzed elements in this study per sector, including as well the ones that could not be personally verified and from which environmental behaviour was set as "expected" as explained before.

SECTOR 1. COMPANY'S EMS. BASES AND PRINCIPLES

First of all, it is remarked that the TK-Hagen's environmental policy statement includes an ample description of the company's commitment on environmental, economic and social aspects. Then, from the information in Figure 6.3, it is noticed that the company's EMS bases, principles and objectives are considered as environmentally proactive oriented, which means that all the company's actions with the potential of generating significant environmental impact should take into account sustainable methods and the precautionary principle in their management.

Besides stating economic and environmental factors, TK-Hagen's environmental policy marks also its openness to dialogue with public, and the monitoring and assessment of the impact on the local surroundings. This fact adds a sustainability value to its commitment and at the same time goes beyond on what the ISO 14001 standard requires on the regular basis.

Then, despite of not mentioning any particular activities involving HS in the environmental policy, TK-Hagen assumes responsibility on the impact that its processes and procedures could cause, and states it on its documented EMS, environmental policy and management principles.

Therefore, it would be expected that sectors from 2 to 9 behave environmentally proactive and active (*levels A and B* respectively); however, from Figure 6.3 can be noticed that some elements reaches just to the legal acceptable category *(level C)*. Yet, in order to assert about the reasons and then recommend improvement measures, it would be necessary to have a deeper understanding on the decision making process of the plant's management (for example, through the application of the proposed interviews),

Consequently, at the moment, these elements on *level B* and *C* represent obstacles for the upgrading of the corresponding sectors environmental performance, and therefore the continuous improvement of the company's EMS of HS.

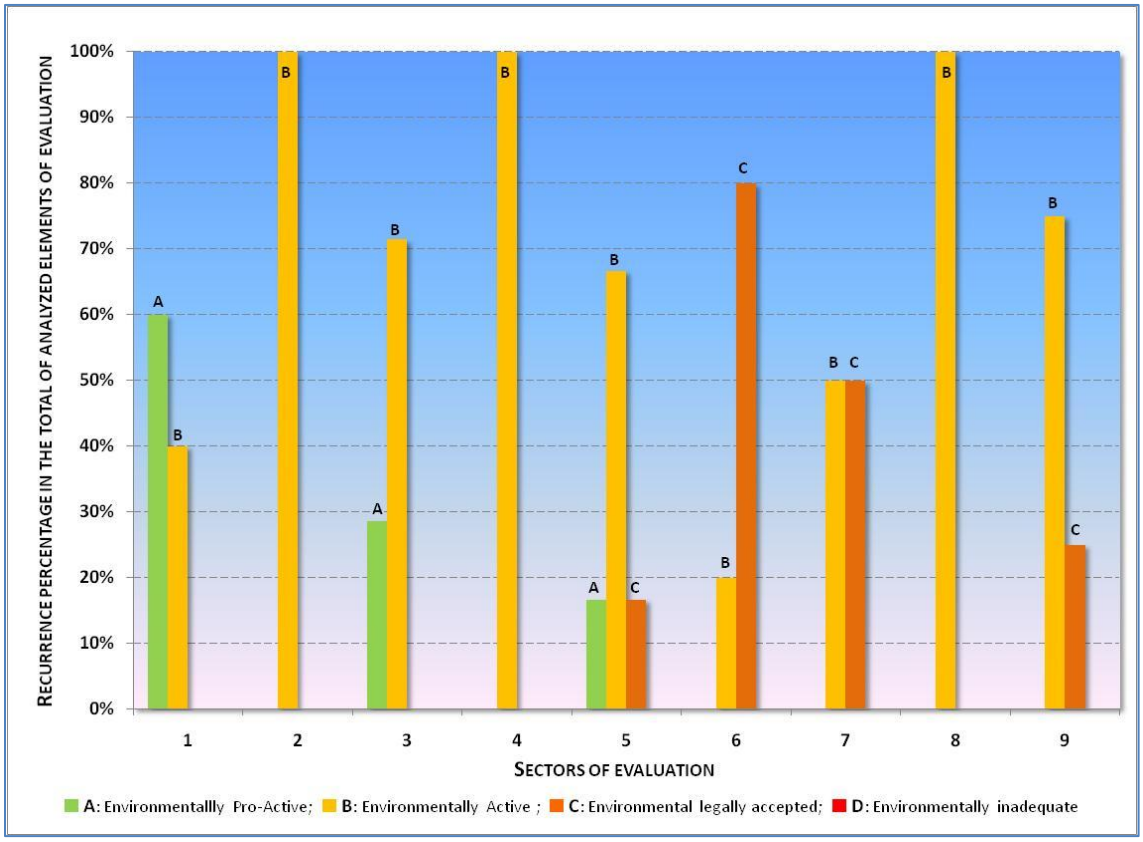


Figure 6.3 *Sectors' results graphic from TK-Hagen elements categorization.*
Sectors of evaluation in the graphic: ***1.*** *Company's Environmental Management System principles and characteristics;* ***2.*** *Head managers;* ***3.*** *Workers involvement;* ***4.*** *Occupational Health and Safety - Storage and Use of HS;* ***5.*** *HS as input materials;* ***6.*** *HS Waste Treatment;* ***7.*** *HS as final company's generated waste;* ***8.*** *Occupational Health and Safety - Hazardous Waste storage;* ***9.*** *HS Final Destination – Knowledge and verification level.*

Particular brief descriptions of each sector's environmental performance obtained after the analysis of the corresponding elements of evaluation are presented in Table 6.1.

The information in this table is concluded from the integration of the obtained categories of each evaluated element, using the information gathered during the fieldwork research done in Hagen-Hohenlimburg, Germany.

It is worth to keep in mind that such descriptions include also the assumptions on the element's "expected" environmental behaviour, since interviews and supplementary visits could not been carried out during the fieldwork research. However, it is also included how this element would be evaluated in ordinary circumstances, order to bring more accurate description of the evaluated sector.

Table 6.1 *Description of environmental performance for each sector of evaluation in TK-Hagen.*

SECTOR	DESCRIPTION
2. ***Head managers***	Environmental performance is expected to fall between the active and proactive range, based on the EMS's resulted category, since the established structure, development and implementation of such system was done by the head managers themselves. HS management, do not show significant changes in the technology of the processes. On the other hand, there is information indicating interest on the introduction of less hazard substances. From this, it is perceived that head managers in TK-Hagen are looking forward to adapt such process in the environmental pro-active range; however, this element cannot be marked as *level A* as long as those adaptations are not implemented. *Note: In this particular sector, all environmental elements' categories were assumed; it is needed to carry out an interview, guided by questions set on Document PM.1, in order to have a more accurate description of the sector's environmental performance and upgrading opportunities.*
3. ***Workers involvement***	TK-Hagen's environmental policy marks pro-active behaviour on workers involvement by including environmental commitment awareness, risk communication, emergency preparedness and promoting ideas to improve process and procedures. Risk and emergency preparedness elements were detected on the visual inspection of TK-Hagen's plant with the constant use of complete protective personal equipment (PPE). Then, in order to confirm the expected environmental behaviour of the sector, personal interviews with the line workers are needed, guided by the set of questions in Document WI.1.
4. ***Occupational Health and Safety - Storage and Use of HS substances***	Legal compliance guides the planning and document control of the sector (e.g., MSDS, emergency plans). Continual internal audits on its supervision supports active category on the environmental behaviour. Procedures and practices are documented and described under consideration of ISO 14001 and OHSAS 18001. Workplace safety was considered appropriate in the area in which HS were used, since it was identified the presence of emergency signalization and infrastructure (e.g., showers and fire extinguishers). On other hand, since storage site element's performance are assumed to comply with legal, ISO 14001 and OHSAS 18001 requirements, inspection of the storage site input materials would be recommendable in order to support this information and propose upgrading opportunities.
5. ***HS as input materials***	Environmental performance is mostly in the active range, starting from the statement of suppliers' requirements on the EMS of the company; then, HS are identified in its majority as well as the risk they represent and emergency preparedness required, and finally the recovering of HS for its reuse is efficient, though it could be improved with more automated procedures. Interest on research for replacement of involved HS marks a proactive orientation of the sector, which in time would bring a significant improvement of the whole sector if such replacements are effectively implemented. Actual technology performance level in the processes is acceptable and does not represent a significant impact from the legal standpoint; however, efficiency on HS use should be improved in order to consider a significant continuous improvement in the sector.

Table 6.1 *Description of environmental performance for each sector of evaluation in TK-Hagen (cont.).*

SECTOR	DESCRIPTION
6. ***HS Waste Treatment***	According to the applicable German regional regulations, resulted treated wastewater and the involved process do not represent significant impact on the environment. In the same way, the extension of HS treated in the process is considered sufficient in the legal framework. Then, according to the environmental policy statement, it is expected to have an active level on the research of improvements on wastewater treatment technology, but this needs to be corroborated by the environmental responsible department of TK-Hagen.
7. ***HS as final company's generated waste***	Though final waste's hazard level and generation do not imply at the moment significant legal breaches, upgrade to level B in this sector's environmental performance is dependent on the research and replacement of HS in the processes or introduction of more effective clean technology. On the other hand, due to frequent emission limits considerations on the German legal framework, it is expected that the company present an active environmental behaviour on the constant revision of atmospheric emissions; therefore it should be reflected on a reduction of emissions vs. production rate.
8. ***Occupational Health and Safety - Hazardous Waste storage***	It was verified that waste storage site's management meets legal requirements on planning and registry control, which is considered as an active environmental behaviour due to the similarity on requirements between both sectors. Therefore, it is also expected that storage site for generated waste, be categorized in the same level of environmental performance. However, this information could be corroborated only through site verification, as well as the upgrading recommendations.
9. ***HS Final Destination – Knowledge and verification level***	Informal interviews with the environmental department manager allowed the verification on the company's knowledge on the following stages from the moment HW is collected until it is sent to its final confinement. Though TK-Hagen presents an active environmental behaviour by assuring that providers of such services follow same legal and other environmental standards, there was no disclosure on the treatment's nature for hazardous waste, which obstructs upgrading recommendations for this sector. On the other hand, it is assured legal environmental acceptance for waste treatment.

6.1.2 Strengths and Opportunity areas detected.

First, it is worth to mentioning that the identification of specific opportunity areas is done through comparing each element's obtained performance with the one required by the applicable regulatory framework, and/or the desired one, according to the environmental priorities established on the company's EMS bases and principles, adding as well the own evaluator's perspective on the need of improvements supported on the concepts of precautionary principle and sustainability.

Then, a complete list of specific recommendations for improvement of each identified opportunity area is given to the company using as a base ***Document ROA.1*** *(Appendix A.7)* However, in both particular study cases this information is kept undisclosed due to confidentiality reasons.

Nevertheless, this section presents the strengths and opportunity areas on the HS management identified in TK-Hagen by sector of analysis in a generalized manner, integrating for the categories of the corresponding elements of evaluation.

Then, to start with the company's EMS of HS strengths, it has been noticed that the company has a sufficiently defined and well elaborated environmental policy (sector 1***. Company's Environmental Management System principles and characteristics***), from which the objectives and environmental principles integrate concepts of sustainability and precautionary principle, which denotes an environmentally proactive orientation from the top management on environmental care issues.

Then, though there is no specific mention on HS management, this is implied by the established commitment of TK-Hagen's with employees' safety, environment integrity and minimum impact and open dialogue with society in the local surroundings.

As a result, it can also be noticed that no elements were identified as environmental inadequate, which could be taken as sign of functionality and consistency of the EMS management. Nevertheless, it is worth remarking that in order to confirm such functionality, it is necessary to revise all the elements whose category was brought from an "expected environmental behaviour" based on the company's orientation.

Nonetheless, it is implied that the company's activities involving HS should be oriented to reach *level A* of environmental performance, but this is not fully observed in all sectors of evaluation. For this reason, recommendations should be taken into account in order to upgrade such performance.

An important area of opportunity identified points to motivate research and effective implementation on either replacement of HS in the actual processes, or the research for more efficient technology or the adaptation of the present one, suggesting more automated and efficient procedures that could reduce amounts of generated waste, less hazard level, minimize atmospheric emissions, and reduce workers' exposure to HS risk. Subsequently, this would

improve also environmental performance on sectors 4, 5, 6 and 9 (***Occupational Health and Safety - Storage and Use of HS substances***, ***HS as input materials***, ***HS Waste Treatment*** and ***HS Final Destination – Knowledge and verification level***, respectively).

Then, in order to improve environmental performance on elements that already have reached acceptable legal behaviour, like those on sector 7 (***HS as final company's generated waste***) and subsequently actually meet environmental continuous improvement, it is recommended the development of own Environmental Performance Indicators (EPI)[11] and the self-establishment of goals that limit environmental impact, taking into account for example guidelines on exposure limits from the World Health Organization (WHO).

Nevertheless, in order to establish more specific recommendations for the EMS of HS, it is required a deeper verification on the elements on sectors 2, 3, 4 and 8 (***Head managers***, ***Workers involvement***, ***Occupational Health and Safety - Storage and Use of HS substances*** and ***Occupational Health and Safety - Hazardous Waste storage***, respectively). This would involve the application of the corresponding interviews proposed in the evaluation tool (i.e., Document EMS.1 part B and C, WI.1, and PM.1); as well as visual inspections in the plant (Document VI.1) and particular documents revision (e.g., MSDS and documented procedures of the activities involving HS).

6.1.3 Environmental performance and conclusion on the hazardous substances in TK-Hagen.

Finally, it is concluded that TK-Hagen HS management presents a predominantly active environmental behaviour, fulfilling in its majority not only legal but ISO 14001 and OHSAS 18001 standards. Additionally, the EMS points out that the activities in TK-Hagen are proactively oriented, and it is expected that through the effective adoption of the continuous improvement concept, the HS management could reach *level A* of environmental performance.

From this, it can be said that TK-Hagen counts at the moment with a functioning EMS of HS that is frequently revised and maintained. The company establishes its commitment on environmental care with the authorities, public and the own members of the organization.

This proper functionality gives additional advantages to TK-Hagen into the international market, which at the present time demands certified management on the industrial practices and prove of low environmental impact. Then, TK-Hagen appears as a competitive company that looks forward for improvement on its practices and demonstrates it by the adoption and fulfilment of such standards.

[11] *EPI are adapted indicators designed to evaluate the EMS performance at industrial plant level. For further description see Chapter III, section 3.1.3.3.*

On the same way, TK-Hagen's environmental behaviour presents at the moment low vulnerability against legal changes on environmental requirements issues. However, in order to continue with this situation it is required:

- Increase on the research for replacement of HS in the company's processes.
- Efficiency improvement on the HS management, by the adaptation of the technology involving their use and treatment, in order to reduce hazard level on the generated waste as well as the quantities of hazardous waste generation.
- Development of EPI that facilitate self-assessment on environmental performance, taking into account international standards on human's exposure to HS (e.g., WHO guidelines).

However, it is worth considering better preparedness for future increase on the production rate in the company. Therefore, in order to avoid possible future legal breaches, it is recommended to develop appropriate preventive measures.

Taking into consideration such recommendations would lead to the upgrading of the level of environmental performance of the studied process in TK-Hagen (i.e., Pre-treatment, Coating and Wastewater Treatment), and would bring additional benefits to the company, like: low vulnerability against legal changes on environmental requirements; savings on chemical product inputs quantities, energy consumption and waste management costs; and as mention before, improvement on the international market opportunities.

Nevertheless, it is important to remark that in the particular case of TK-Hagen in order to have more accurate sectors' descriptions and recommendations, the evaluation results need to be verified through additional plant inspections, documents revisions and interviews with the organization members on the different levels involved in the HS management (i.e., production line workers, processes managers and environmental department managers).

6.2 EMS OF HAZARDOUS SUBSTANCES. INDUSTRIAL PLANT IN SAN LUIS POTOSÍ, S.L.P., MÉXICO.

The presented results were obtained in accordance with the analysis of the information gathered from the visual inspections, personnel interviews and documents revision, done on the two-part fieldwork research held on June 2009 and May 2010, as mentioned on the study cases description *(see Chapter IV, section 4.4)*.

As a general description, Figure 6.4 can give a small introduction on the results obtained in the hazardous substances management held by TK-SLP involved in the processes of Pre-Treatment, Coating and Wastewater Treatment. According to this, it can be said that the company has presented for the most part two types of environmental behaviours: **Environmentally active** *(B, 50%)* and **Environmental legally accepted** *(C, 28%)*, which is in its majority consistent to the ISO 14001 guidelines followed by the company's EMS since 2008.

On the other hand, the categorization of some elements as **Environmentally Proactive** *(A, 14%)* and **Environmental inadequate** *(D, 8%)*, though in minor scales, both are relevant to considered since the first one resulted mainly from the environmental elements' analysis from sector *"1. Company's EMS. Bases and Principles"*, which means that the company has a supporting standpoint on the orientation of its activities based on environmental care and sustainability; on the other side, it is also important to attend the minor presence of elements that could be probable signs of inadequate management of hazardous substances, develop corrective actions and implement them in order to avoid legal breaches.

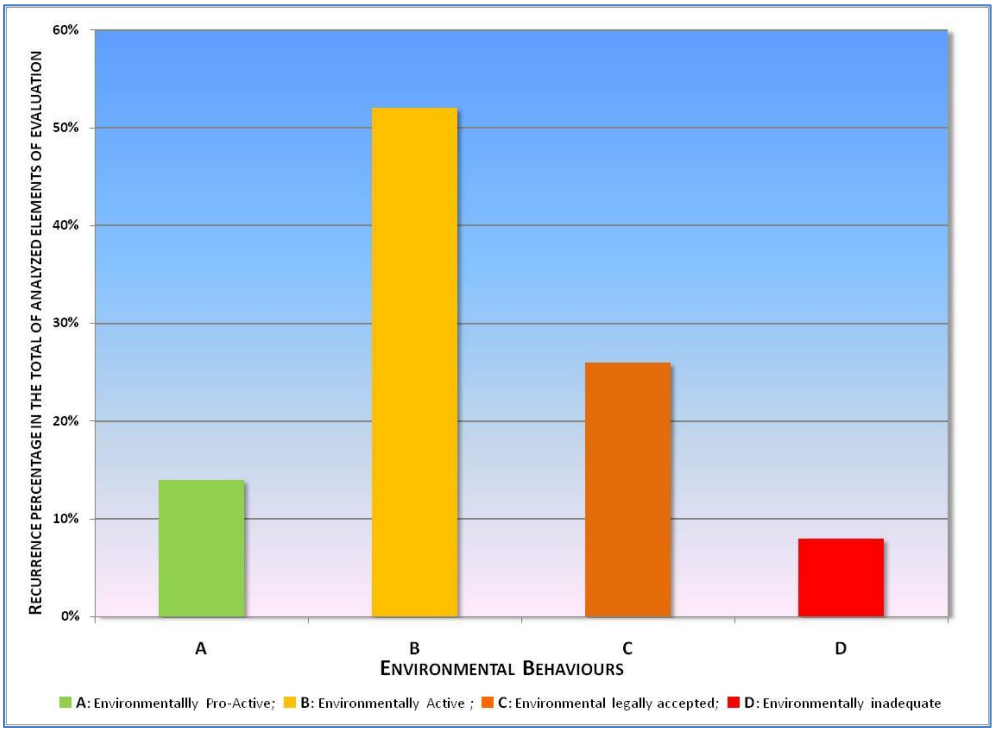


Figure 6.4 *Results graphic from elements categorization in TK-SLP.*

6.2.1 Environmental behaviour by sectors of evaluation.

In order to have a better understanding of the results presented on Figure 6.4, this section describes the obtained performance per sector of evaluation according to the proposed method *(described in Chapter V, section 5.2)*. In Figure 6.5 can be identified which are the sectors that meet environmental proactive characteristics and which need to be improved.

Then, as in the precious case, it is worth reminding that these descriptions do not include the particular results for each element of evaluation; however, this is included in the TK-SLP's final technical report of this research.

SECTOR 1. COMPANY'S EMS. BASES AND PRINCIPLES

According to the results presented in Figure 6.5, it can be said that the company's EMS bases, principles and objectives are mainly oriented to fulfil international basic standards on environmental responsibility that move forwards the company in the competitive international market.

Nevertheless, the company makes also inclusion of some elements that point the pursuit of sustainability in their energy and resources consumption, which are part of the environmentally proactive level. However, an interest on enhancing public involvement is not pointed out as one of the company's priorities, which could be related to the fact that the company is located in an industrial zone of the city, relatively far from urban households. Nevertheless, due to this exclusion, it cannot be marked that the bases of the company's EMS work in an actual sustainable framework.

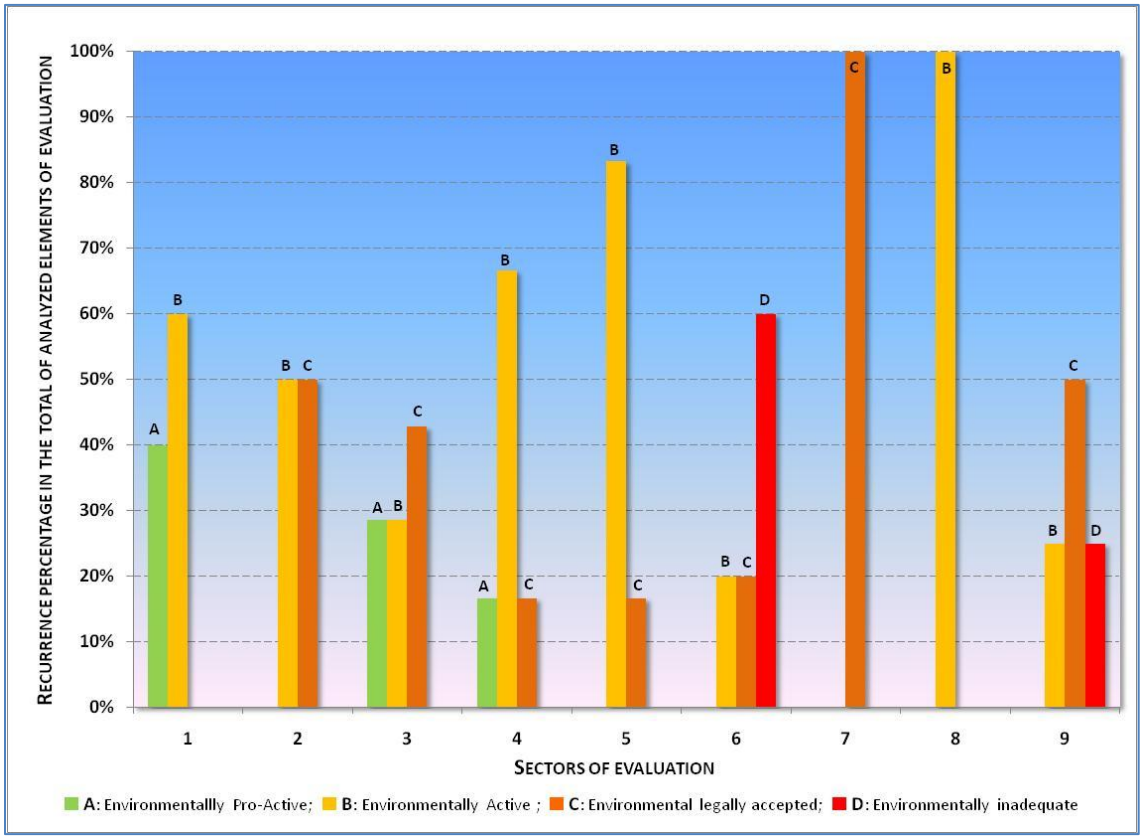


Figure 6.5 *Sectors' results graphic from TK-SLP elements categorization.*
Sectors of evaluation in the graphic: ***1.*** *Company's Environmental Management System principles and characteristics;* ***2.*** *Head managers;* ***3.*** *Workers involvement;* ***4.*** *Occupational Health and Safety - Storage and Use of HS substances;* ***5.*** *HS as input materials;* ***6.*** *HS Waste Treatment;* ***7.*** *HS as final company's generated waste;* ***8.*** *Occupational Health and Safety - Hazardous Waste storage;* ***9.*** *HS Final Destination – Knowledge and verification level.*

Yet taking this into account, it is expected that all sectors from 2 to 9 be oriented to the active and proactive behaviours (*levels A and B*). Then, eventually all sectors' environmental performance should reach level A of environmental performance. However, more effort needs to be invested in order to improve the elements with detected inadequate environmental performance (*level D*).

Then, it is also worth mentioning that the head managers should take into account the development of sets of self-improvement indicators that overpass legal requirements, in order to upgrade the sectors and elements categorized in level B and C.

After having mentioned this, a brief resume of the rest of the sector's environmental performance is presented in Table 6.2, which results from the comparison of the obtained results with the mentioned company's priorities and bases orientation on environmental care.

Table 6.2 *Description of environmental performance for each sector of evaluation in TK-SLP.*

SECTOR	DESCRIPTION
2. ***Head managers***	Priorities from head managers are focused on meeting first of all legal requirements then ISO 14001. Environmental risk on HS management issues are sufficiently understood, but the ability to solve or address them is limited due work load issues and priority on attending economic and product demand issues.
3. ***Workers involvement***	Attached primarily on requirements on HS management; however mainly immediate risk is perceived, not long-term. Though, knowing environmental policy, it is scarcely noted identification of related elements, which denotes limited involvement. On the other hand, frequent safety training programs and ideas promotion for processes' improvement denote proactive orientation that in time could break the mentioned limits.
4. ***Occupational Health and Safety - Storage and Use of HS substances***	The similarities between legal framework and ISO 14001 requirements, and their satisfactory fulfilment by TK-SLP management, make the sector to be present an active environmental performance according to the obtained results. Additionally, the wild structure and organization on planning and registry control in HS storage and use, as well as the technology introduction in the process (i.e. dust-recover cyclones) to reduce dust exposure, indicate self improvement interest. Nonetheless, it is recommended that personal protective equipment use and surveillance be improved to fully reach *level B* and then *A* in the corresponding elements of evaluation.
5. ***HS as input materials***	All HS are properly identified and its management meets legal requirements; additionally, compliance with ISO 14001 requirements is noticed by the organization and document control in the sector, as well as by the materials suppliers' verification. However, low research on current HS replacement in the processes is the main factor that limits the upgrading on the sector's environmental performance to *level A*.
6. ***HS Waste Treatment***	Though the type of technology used suggests no environmental impact and most of the treatable HS residuals are included in the process in the company, there is few documented information and control registry in the process involved. This could result in environmental issues or even legal breaches, and need to be solved to prevent these situations and subsequently upgrade the sector's environmental performance.
7. ***HS as final company's generated waste***	The final waste is identified, handle and contained as the corresponding Mexican norms indicates, supporting this information by authorized laboratories reports and empirical knowledge on the waste's hazard level, what makes the sector environmental performance mainly legally acceptable. However, after analyzing the process it is recommendable to verify the classification in the case of non-hazardous waste. Additionally, the non-reduction on the rate of generated waste and atmospheric emissions vs. production, limits continuous improvement in this sector.

Table 6.2 *Description of environmental performance for each sector of evaluation in TK-SLP (cont.)*

SECTOR	DESCRIPTION
8. ***Occupational Health and Safety - Hazardous Waste storage***	As in sector 4, this case legal and ISO 14001 requirements are relatively close. Therefore, the company's HW management has an established structure on registry and -planning, as well as containers and site safety measures are attached to the legal framework requirements. Nonetheless, in order to upgrade to level A on environmental performance, it is recommended to consider safer site conditions (e.g. designation of larger area, increase containers segregation), which though no legal breaches were yet detected, would prevent risk situations when waste quantities augment.
9. ***HS Final Destination – Knowledge and verification level***	The company meets legal responsibility maintaining required records on consignment notes and contracting services from a legal authorized HW management company. On the other hand, upgrading environmental performance is restricted due to the regional limitations on HW management, since incineration is considered an activity that causes negative environmental impact.

6.2.2 Strengths and Opportunity areas detected.

As in the previous study case, specific opportunity areas are identified by comparing each element's obtained performance with the required performance by the applicable regulatory framework, and/or the desired one, according to the company's EMS bases and principles and the own evaluator's perspective on the need of improvements supported on the concepts of precautionary principle and sustainability.

On a regular basis, a list of specific recommendations for improvement of each identified opportunity area should be included in the designated spaces in ***Document ROA.1*** *(Appendix A.7).* However, as mention before this information is kept undisclosed due to confidentiality reasons.

Yet, in order to preserve an overall perspective on the HS management in TK-SLP, this section presents the strengths and opportunity areas identified by sector of analysis in a generalized manner.

First of all, regarding strengths of the company's EMS of HS, a opening positive aspect to remark is the supporting background on environmental care and energy and resources sustainable management that has been stated in the company's EMS bases and principles.

Then, it is pointed out that while all sectors have demonstrated to meet most requirements established by the corresponding Mexican regulatory framework and the ISO 14001 standard, it is also noted that an environmentally proactive behaviour was presented in the sectors 3 and 4 (***Workers' involvement*** and ***Occupational Health and Safety – Storage and use of HS***, respectively). This denotes a significant interest from the company's head managers on providing a safe and positive working environment for these production line's employees.

Additionally, since all elements in sector 8 ***(Occupational Health and Safety – Hazardous Waste (HW) storage)*** shows an active environmental behaviour that meets legal and ISO 14001 requirements, it is noted that the sector is close to upgrade its environmental performance, on condition that better safety measures be implemented. In order to do this, it is needed to take into account precaution measures that consider future increase on waste generation, as well as enforcement in other issues like risk control and emergency preparedness planning.

After this, regarding the EMS orientation, it can be said that most analyzed sectors fulfil with the inclusion of the standard ISO 14001 elements in their structure. In the same way, most of them show accomplishment of Mexican legal requirements, which could also be upgraded with the integration of a revision system that enforces the functioning of the sector.

Additionally, the inclusion of continuous improvement elements is also a recommendation to upgrade all sectors environmental performance, especially 5. ***HS as input materials*** and 7. ***HS as final company's generated waste***. In the first case, a deeper research on the replacement of HS in the process could improve the sector's environmental behaviour possibly to level A; on the other side, introduction of clean technologies in the processes that results in reduction of waste generation or atmospheric emissions, would represent an upgrade of sector 7, from a legally accepted to an active environmental behaviour.

On the other hand, regarding the most relevant opportunity areas to begin with, it is important to prioritize the sectors of evaluation that include elements categorized as inadequate in their environmental performance, referring to sectors 6 and 9 (***HS Waste Treatment*** and ***HW Final Destination – Knowledge and verification level,*** respectively).

In both cases, recommendations point the necessity on counting with supporting documented information on different aspects like: effectiveness of the wastewater treatment process (e.g., authorized laboratories analysis, end-of-pipe measures) and consignment notes from the contracting company (or companies) in charge of treatment and/or confinement of HW.

In the same way, more research is recommended in order to evaluate the introduction of clean technologies that improve the effectiveness on the waste treatment process. However, it is important to point out that due to regional limitations on technologies available for HW elimination, the company is on a limited situation that obstacles the reaching level A of the environmental performance on sector 9.

Another opportunity area is detected in sector 7. ***HS as final company's generated waste***, in which case all elements point to the accomplishment of the requirements established on the Mexican regulatory framework. Nonetheless, the upgrading of the environmental performance in this case relays on the implementation of measures in the process that lead to the continuous improvement, since the state of the elements pointed out that the HW generation *vs.* production rate, as well as the atmospheric emissions *vs.* production rate, from this industrial plant has not effectively changed in the last years.

Finally, a significant opportunity area to consider is the role of ***Head managers*** in the EMS functioning. In this particular case, it is noticed that in sector 2, accomplishment on legal aspects, as well as the fulfilment of standard ISO 14001, are the first elements that have been considered in the decision making process since the EMS implementation. This is considered to be a good start to orient the EMS functioning in an acceptable way, however could also limit its upgrading.

Then, in order to improve environmental behaviour in this sector, it would be recommendable to carry out a stakeholder analysis, in order to identify another interested and affected parties involved in the decision making process, and at the same time could better guide head managers on addressing demands and expectations related to environmental issues.

6.2.3 Environmental performance of the hazardous substances management in TK-SLP.

According to the presented results, it is concluded that the environmental performance of the HS management in TK-SLP falls between mainly two types of environmental behaviours, the environmentally active and the legally acceptable.

This means that at the moment, TK-SLP has a functioning EMS, in which the HS management is included, and that directs its continuous improvement character to the prevention of environment deterioration and correct resources management.

However, despite the inclusion of practical objectives on energy saving and water consumption, the plant's EMS do not include objectives particularly oriented to the improvement of environmental performance on the analyzed activities involving HS management (i.e., acquisition, storage, use, waste treatment, storage and final disposal).

Then, it worth mentioning that in TK-SLP the environmental department as well as processes managers focus their current attention on maintaining environmental performance in the marked range of the applicable Mexican legal framework. From this, the inclusion of environmentally active character is noticed by the voluntarily adoption of a more solid organizational structure that facilitate the revision of the fulfilment of such established legal parameters.

In this matter, it was perceived a work overload in the environmental and occupational safety management department due to the number of issues that require attendance. Therefore, it is recommended to provide assistance on this department, or consider a revision on the distribution of responsibilities among the involved departments.

Afterwards, it is recommendable to attend the marked issues that were identified as inadequate in the actual environmental performance of TK-SLP's HS management, since such elements obstruct the upgrading of the sector's environmental performance (and therefore the one of the own EMS of HS), result in legal breaches that could involve environmental sanctions from the corresponding authorities, and endanger the actual validity of the ISO 14001 certification.

It is required to enhance attention on some other important related matters. For example, it is needed to carry out a more extensive revision of the applicable Mexican norms in order to detect overlooked legal requirements; in the same way, it is recommended to improve monitoring and follow up the progress on corrective actions from previous internal and external audits; then, it is also worth considering future increase on the production rate in the company and implement measures in order to prevent possible future legal breaches.

Furthermore, regarding the international market in which TK-SLP participates, it would be needed to consider international pressure on this matter, since it could also represent changes on the company client's demands (e.g., specifications on carbon footprints by the product, use of green technologies on the processes) or even future amendments on the ISO 14001 certification.

Finally, it can be pointed out that the current HS management in TK-SLP present vulnerability in front of the possible future amendment Mexican legal regulations. This issue could become more noticeable in the future with the probable introduction of more legal requirements on HS management by the Mexican authorities, which is expectable taking into account the increasing pressure from international organizations that promote more control of industrial practices and better HS management.

6.3 COMPARISON OF ENVIRONMENTAL PERFORMANCE BETWEEN EMS OF HS FROM THE TWO PLANTS OF THE GERMAN-MEXICAN INDUSTRIAL COMPANY.

Both study cases, TK-Hagen and TK-SLP, are industrial plants part of the steel manufacturing *Bilstein Group* of the company *ThyssenKrupp AG*. Additionally, both companies include almost the same products and processes, as well as similar technology and use of similar hazardous substances (HS).

For these reasons, it is useful to make a comparison between both systems in order to bring up opportunity areas that allow the identification of particular issues on the HS management, in which the crossing of information between both plants' managers would lead to the improvement of the environmental performance of each system.

However, it is worth mentioning that in order to have more accurate outcomes from such comparison, verification of the elements of evaluation of TK-Hagen is needed, since about 40% of the elements of evaluation were categorized on the assumption of an "expected" environmental response, based on TK-Hagen's established environmental policy and principles, as well as additional comments from informal interviews held during the fieldwork research.

After having clarified this, the comparison is done mainly as an informative exercise that show the suggested method for comparing the environmental performance between two plants of the same company from the results obtained after the application of the proposed evaluation tool.

RESULTS INTEGRATION, GENERAL RECOMMENDATIONS AND COMMUNICATION

In Figure 6.6 is presented an integration of the results obtained from both plants' evaluations, which includes graphics of sectors evaluation of TK-Hagen and TK-SLP, presented on *sections 6.1.1* and *6.2.1* respectively. The aim of this is to recognize similarities on environmental behaviour in the different sectors, as well as main differences that would bring up strengths and opportunity areas between both systems.

After the analysis of Figure 6.6 and taking into account the individual EMS descriptions and recommendations, it can be seen that both present some recommendations in common for the improvement of the company's HS management, which are:

1. Increase on research for replacement on HS in the process.
2. More efficient technology that minimize workers' health and environment exposure, and/or reduce quantities of hazardous waste generation.
3. Development of own EPI guided on environmental and human health care international guidelines (e.g., from WHO, UNEP).
4. Enforcement on the monitoring and elements revision hold through the internal audits, as well as crossing of available auditors between both plants to carry out those revisions and reduce evaluator's bias in the results interpretation.

The consideration of such recommendations would imply the analysis from the managers of both plants. Nevertheless, a joint action between them on the planning and implementation process of any improvement measure would probably lead to better outcomes and more efficient procedures.

Then, the next thing remarked is the prevalence of an active environmental behaviour in both plants. This is probably a result of the adoption of ISO 14001 guidelines on the implementation and revision of both plant's EMS, which includes the HS on the studied processes of Pre-treatment, Coating and Wastewater Treatment. On the other hand, this is also the first aspect in which is founded the most important opportunity area that would bring up benefits between both plant's EMSs.

According to the information provided by the environmental department in TK-Hagen, both plants should be guided under the same environmental policy and principles, as well as the same environmental management handbook.

Therefore, a communication break is found, since in TK-SLP the EMS management was developed by their own environmental management department and, despite being also certified under

standard ISO 14001, it has a shorter environmental policy and more specific objectives; in contrast with TK-Hagen, that counts with a Moreover, it does not include the integration of the requirements from the standard OHSAS 18001.

Therefore, it is comprehensible that both systems present differences on the HS management, besides of the already expected ones from the adaptation to the legal framework of the corresponding country.

Subsequently, it is recommended to enforce the communication channel between the environmental management departments of TK-Hagen and TK-SLP, since this is needed in order to effectively carry out the recommendations further described. Additionally, such enforcement could also bring improvements in the production processes regarding product's quality as long as it is expanded in different management areas of the company.

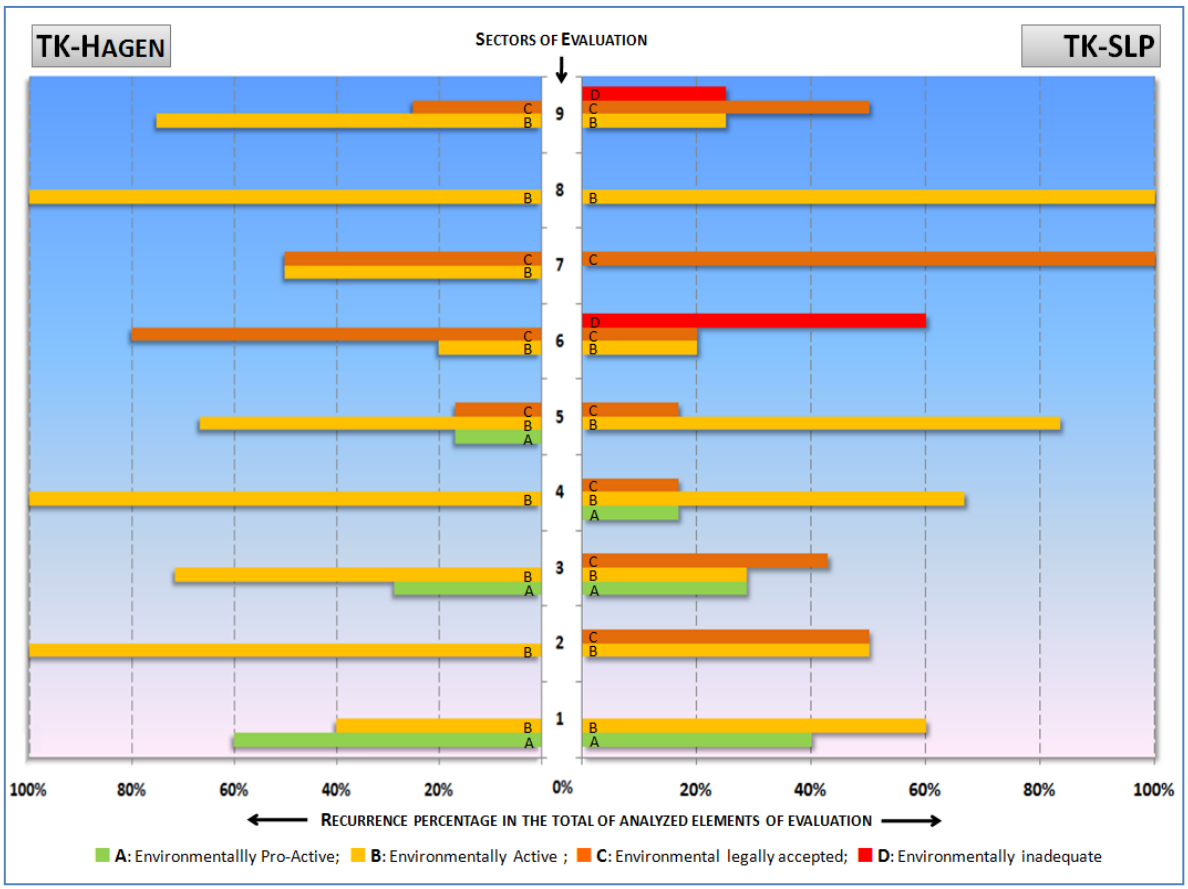


Figure 6.6 *Comparison graphic of sectors' environmental behaviour between TK-Hagen and TK-SLP.*
Sectors of evaluation in the graphic: ***1.*** *Company's Environmental Management System principles and characteristics;* ***2.*** *Head managers;* ***3.*** *Workers involvement;* ***4.*** *Occupational Health and Safety - Storage and Use of HS substances;* ***5.*** *HS as input materials;* ***6.*** *HS Waste Treatment;* ***7.*** *HS as final company's generated waste;* ***8.*** *Occupational Health and Safety - Hazardous Waste storage;* ***9.*** *HS Final Destination – Knowledge and verification level.*

OPPORTUNITY AREAS BETWEEN BOTH PLANT'S EMS OF HS.

Regarding the sectors of evaluation, it is first noticed that in the case of TK-Hagen most of the evaluated sectors present a higher level in their environmental performance than the ones in TK-SLP.

On a regular basis, this would mean that TK-Hagen's EMS has a more efficient functioning than the one in TK-SLP; however, it is important to remember that such results are in part "expected" and for that reason they must be verified, since enough information that support the obtained categories could not be gathered.

Considering this, it can just be said that TK-Hagen counts with a more explicit organizational structure on the EMS of HS which integrates elements of sustainability and precautionary principle in the environmental policy definition and objectives *(sector 1.* ***Company's Environmental Management System principles and characteristics****)*. Therefore, it is recommended to take these EMS elements from TK-Hagen be taken into consideration in order to improve the one established in TK-SLP.

Additionally, at the moment information from managers in TK-Hagen points to the possible replacement of some HS used as pH buffers in the process by other ones less hazard *(sector 5.* ***HS as input materials****)*; it is then recommended to analyze the possibility of making such replacements too in TK-SLP, taking into account their actual applicability and the corresponding regulations for their management in Mexico.

Moreover, the ultra-filtration procedure to obtain deionized water hold in TK-Hagen represents as well an opportunity of improvement in TK-SLP, since it could also reduce the quantities of HS used in this plant for the same purpose and additionally it would bring up better quality deionized water for the processes that use it and increase quality in the final product's coating.

Another point was that TK-Hagen keeps an acceptable and sufficient document control regarding the knowledge and verification of the final destination of hazardous waste. The sharing of this information would guide to a more solid and efficient performance in sector 9 ***(HS Final Destination – Knowledge and verification level)*** in the TK-SLP's plant.

On the other side, it was found that TK-SLP has a more efficient system of materials recovering in the coating process *(sector 5.* ***HS as input materials****)*, since in this case the recollection method for non-used dust is done automatically by air cyclones, and only the maintenance of cabins is manual; the implementation of such systems in TK-Hagen, where both non-used paint collection and maintenance procedures are manual, would reduce considerably health exposure risk against dust particles in air.

Moreover, it is expected that wastewater treatment in TK-SLP be more effective in phosphates removal than the one done at the moment in TK-Hagen[12] (sector 6. ***HS Waste Treatment***), due to the addition of iron (III) chloride in the flocculation step in the first plant.

Then, even if this parameter is not a required to be monitored according to the German applicable regulations, a better quality on the treated wastewater could permit its use in other areas or process of the company, like cooling of heated materials or irrigation (which is done in TK-SLP), representing at the same time a more efficient use of the water as an important resource in the company.

On the other hand, it is recommended that TK-SLP enforces monitoring on the wastewater treatment environmental performance (also sector 6), by improving documented control on the area and taking into account methods applied in TK-Hagen for controlling pollutants discharges.

Then, it is also worth mentioning that TK-SLP demonstrates a particular interest on the emergency risk planning referring the risk involved in the use of HS in the process by the creation, monitoring and maintenance of an "emergency responding team". In this implemented and established program, the company involves a designated group of workers in emergency, safety and health issues by providing special training against fires or other contingencies that may occur in the different areas of the company.

Despite being a legal requirement, TK-SLP promotes incentives to the workers who participate in this program, and at the same diffuses risk awareness by the public exhibition of outcomes from this program and the counting on days without presenting contingencies at the current date.

These described elements of risk planning that integrates workers involvement and increase risk awareness, gives a proactive orientation in the environmental performance in sector 4 (***Occupational Health and Safety - Storage and Use of HS substances***). Then, since there was no information provided on the subject, it is recommendable to apply similar programs in TK-Hagen in order to upgrade its performance on sector 4.

6.4 ADAPTATION REQUIRED FOR THE APPLICATION OF THE EMS EVALUATION TOOL.

The proposed evaluation tool considers general aspects to take into account in the environmental performance description of HS management in the industry. Nevertheless, in order to apply it in both study cases, some adaptations had to be considered during this research.

[12] *Though actual phosphates containing in treated wastewater in TK-Hagen is considered high, it does not represent a legal breach according to the German legal framework (see Chapter II, section 2.4.2.3), since treated wastewater goes to the drain system of the city and phosphates are not required to be monitored on wastewater originated from the metal working or metal processing industry.*

The main similarities between both industrial plants regarding the production chain and main chemical substances in the processes made it easier to use almost the same formats. However, the differences that relay between the both countries legal framework of location made as well differences on the categorization of some elements of evaluation.

Therefore, the first adaptation of the evaluation tool was evaluating each plant's performance considering the corresponding applicable regulations on each plant; after this, emphasis on such differences was done in the comparison exercise between their environmental performances.

Moreover, for further applications of this evaluation tool, it is recommended to add specific elements of revision in order adapt this tool to the applicable regulations, according to the location of the plant of study and the processes that are being carried out. An example of this is shown for the case of the TK-SLP in Chapter V *(see section 5.2.3).*

On a second place, the next adaptation to the methodology was done on the interviewing process with the processes' managers, since the organization on process managers differs from one company to another. Therefore, it is important to consider the possibility of having multiple interviews in order to complete the information needed.

In this aspect, in TK-SLP side there is only one responsible manager in charge of the management and functioning of the three processes of interest (i.e., Pre-treatment, Coating and Wastewater treatment) and one assistant mainly focused on the Coating process. This organization leads to the need of two interviews guided with the ***Document PM.1***, one with the main manager and the other one with the assistant.

On the other hand, in TK-Hagen there is one responsible manager in charge of the Pre-treatment and Wastewater treatment processes, and another one in charge of the coating process. This lead to the need of two interviews guided with this same form, one per manager of the processes involved.

In a third place, it is recommendable that for further applications the evaluator and the evaluated company be aware about the set of activities involved in the methodology, and take into account that the more access to the information is given, the more accurate results can be obtained.

Then, it is important to consider that the information gathered should be as descriptive, complete and verifiable as possible, and to do this the evaluator should consider the use of different media, e.g., records of chemical analysis, photographs of the plant and taped interviews. However, the evaluator should adapt the method to the company's management allowances, keeping always in mind the importance of having the most accurate data in order to have useful outcomes from the study. In both cases of study in this research there were differences on the information accessibility and recording allowances.

In the case of TK-SLP, there were no significant restrictions on the information gathering stage. It was provided supervised and guided access to all sites of interest for the study (as long as the

personal protection equipment was worn) and it was also allowed to take sufficient photographs from the sites and processes. Interviews were done personally and information was obtained directly from the corresponding managers and line workers. All substances' Safety Data Sheets (SDS) were provided by the company as copies from the original ones given by the chemicals suppliers.

On the other hand, there were some management limitations on the information gathering in the case of TK-Hagen, as well as other difficulties out of the hands of the company's managers and of the researcher. In this case, though visits to the production area were done under the corresponding managers' supervision and guidance, the visits to the chemicals input materials and hazardous waste storage sites couldn't be done due to time availability; in the same some interviews couldn't be realized due to difficulties presented, but the ones held were done personally. Then, in contrast with TK-SLP, there was no company's authorization on taking photographs of the different production areas, and the name and SDSs of the chemicals used in the Coating process were also undisclosed. Therefore, in this case it was considered that best method was taking descriptive notes, transcribing them and personally verifying them with the corresponding managers in the plant.

Finally, it is important to consider that, since this method was originally developed in order to fit to the studied company industrial branch as well as to the processes of study and the chemical substances involved, its adaptation for further applications should take into account how the different sectors of evaluation and specific elements proposed need to be adapted in order to fit different cases.

For example, a company that does not include wastewater treatment in its processes that involve HS would not be necessarily considered as environmental inadequate. In this case, the situation should be analyzed in order to decide whether it is legally required, then if it is possible and/or practical to include this in the plant's activities. From this, the environmental performance has to be discussed by the evaluator, as well as the adaptation of the sector's descriptions or its elimination.

CHAPTER VII.

CONCLUSIONS AND RECOMMENDATIONS

The worldwide spread on the use of hazardous substances (HS) in industrial processes has brought the increase of international concern on their adequate management. Additionally, the development of international guidelines of Environmental Management Systems (EMS), such as ISO 14001 and EMAS, and their adoption by the industrial branch have represented an important contribution on the subject.

However, environmental performance of the HS management of the industrial companies cannot be inferred only by the compliance with applicable regulations or the implementation of these EMS standards.

In the present study it was analyzed an EMS of HS in a German-Mexican industrial company through the application of an evaluation method that categorized the environmental performance of different aspects on HS management.

This project was conducted under the requirements of the International Master Programme (M.Sc.) on Environment and Resources Management for Latin American and German young professionals of the Autonomous University of San Luis Potosí *(Universidad Autónoma de San Luis Potosí)* and the Cologne University of Applied Sciences *(Fachhochschule Köln)* with the support of the National Council on Science and Technology (CONACYT) and the German Academic Exchange Service (DAAD).

The cases of study in this research were two industrial plants of the steel manufactory branch: *ThyssenKrupp Bilstein Suspension* (TK-Hagen) located in Hagen-Hohenlimburg, Germany and *ThyssenKrupp Bilstein Sasa* (TK-SLP), located in San Luis Potosí, Mexico.

Both analyzed cases referred to certified EMS under the standard ISO 14001:2004, as well as the same processes to study (i.e., Pre-treatment, Coating and Wastewater Treatment), though with minor differences between technology and specific HS applied. Other differences were presented among the requirements according to the national regulations to which each EMS was subjected to.

The evaluation method for the EMS of HS developed in this research presents the following characteristics:

a. Integration of the safety measures on the HS management on national (specifically German and Mexican) and international regulatory frameworks, with the issues that influence on the functionality of an EMS (e.g., environmental policy, organization commitment) considering main components from international standards on this matter (i.e., EMAS and ISO 14001).

b. Contemplation of the different stages involved in the HS management, such as: acquisition, storage and use of such HS as input materials; as well as the treatment, temporal storage, transportation and final disposal (e.g., confinement, incineration) of the produced hazardous waste.

c. A systematic revision of 50 selected environmental and management elements that were organized in nine sectors of evaluation:
   1. Company's Environmental Management System principles and characteristics
   2. Head managers
   3. Workers involvement
   4. Occupational Health and Safety - Storage and Use of HS
   5. HS as input materials
   6. HS Waste Treatment
   7. HS as final company's generated waste
   8. Occupational Health and Safety - Hazardous Waste storage
   9. HS Final Destination – Knowledge and verification level

d. Use of five types of checklists that require: interviews among personnel of different organizational levels involved (i.e., line workers, processes managers and EMS responsible managers), documents revision (e.g., MSDS of HS, laboratory analysis) and plant's inspections (e.g., in the line processes, storage sites).

e. Description of the environmental performance through a comparison method between obtained answers and the information of the developed matrix for this evaluation tool. This matrix sets, for each element of revision, four types of probable responses according to the level of environmental performance or *environmental behaviour*:
   Level A. *Environmentally proactive*
   Level B. *Environmentally active*
   Level C. *Environmental legally accepted*
   Level D. *Environmentally inadequate*

f. The proposed evaluation method is applicable to small, medium or large industrial companies or manufacturing plants that involve HS in their production processes, and which management recognize the benefits that result from environmental performance improvement in the company, like: costs savings on resources consumption, prevention of legal breaches, public recognition and increase on the international market opportunities by assuring environmental responsibility.

g. The adoption of the proposed method in this study, in these plants or other further applications, does not represent significant costs for the company in a regular basis, since it can be applied as part of the internal auditing system.

h. The time required for the application of this evaluation method for EMS of HS, depends on the evaluator's level of knowledge of the involved processes. In any case it is estimated a maximum of two weeks, considering regular labour hours, of full time investment.

i. The method's reliability and validity depends on the specificity of the elements of evaluation, veracity of the information provided and the evaluator's profile according to the required supporting background.

The developed methodology was applied in both cases of study and, according to the obtained results, it is concluded that:

a. The majority of the analyzed sectors in both plants (TK-Hagen and TK-SLP) presented mainly environmentally active behaviours, but the levels of proactive orientation and legally accepted environmental behaviour differ from one company to the other.

b. The categorization of the obtained results enabled the identification of the strengths and opportunity areas in both cases of study. From this, it was found that the developed method facilitated the detection of possible legal breaches and at the same time its adoption would enforce the revision system for the current EMS and consequently, contribute to its continuous improvement process.

c. Recommendations of improvement were summarized for both plants, TK-Hagen and TK-SLP individually, but presented significant differences on the accuracy of the final outcomes.

d. Results and categories obtained from TK-Hagen need corroboration, since about 40% of the elements of evaluation were categorized from "expected" environmental responses (due to the difficulties presented that prevented supplementary plant visits, interviews and additional documents revision). Therefore, some recommendations were generalized, while others were only directed towards the improvement of sectors with verifiable information.

e. The outcomes in TK-SLP were more accurate and useful to identify improvement opportunities in sectors of HS management and indicate the ones of priority attendance. It was pointed out the need of a more efficient organization on the responsibility distribution on matter of HS and environmental management.

The comparison exercise between both plants' results allowed the identification of aspects in which crossing of information between the management departments of the two industrial plants would bring improvements on the environmental performance of their respective EMS of HS (i.e., EMS structure, workers involvement, use of HS and technology applied). However, it was pointed out the necessity of enforcing the communication channel between managers of both plants, in order to implement those recommendations.

The comparison exercise presented an additional use of the developed tool and simultaneously, supported its functionality from the benefits that its application could bring into the industrial practice.

RECOMMENDATIONS FOR FURTHER APPLICATIONS AND RESEARCH.

Some observations can be done in order to guide further improvements on the application of the proposed evaluation tool and obtain more accurate and useful results and recommendations.

To begin, it would be important to consider the inclusion of a time frame indicator in the evaluation checklists, in order to indicate whether the obtained answer would change or not within time. This adaptation would be useful to project the functionality and consistency of the EMS of HS in a period of time, prevent environmentally inadequate situations or downgrading of the element's environmental performance.

Another aspect to comment is that, since this is a qualitative method of evaluation and no scales or mathematical operations are included, much of the final analysis and results interpretation lay on the evaluator's skills on the information integration. In the same way, the categorization of the elements' environmental performance would probably be influenced by the evaluator's bias.

This aspect was discussed in Chapter V *(section 5.4)* and it was suggested that this evaluation tool be applied by an auditor counting with a supporting background on concepts of environmental care, sustainability and precautionary principle. However, some aspects to improve could be considered in order to reduce subjectivity in the evaluation process and contribute to the reproducibility of results.

Another aspect to consider is to strengthen differences between environmental behaviours' descriptions of particular elements, according to the four proposed environmental behaviours. For example, it is suggested to mark more distinctions between legally accepted and active environmental behaviours in sectors like 4 and 8 (*Occupational Health and Safety - Storage and Use of HS and Occupational Health and Safety - HW storage*, respectively) in which document and registry control, planning, training programs and frequent revision are part of the legal requirements and simultaneously part of the requirements of important international management guidelines (i.e., ISO 14001 and EMAS).

A further improvement opportunity is the integration of a weighting system that differentiates between the environmental elements' significance in each sector of evaluation, providing scales in accordance to its particular environmental impact or to the influence on the upgrading of the sector or to the relevance.

The integration of such system would better guide the evaluator in order to categorize and describe the environmental behaviour of the whole sector of evaluation. However, it is worth

taking into account that, since the introduction of such system would sacrifice subjectivity in favour of the study reproducibility, it also could sacrifice valuable contributions from the evaluator's expertise as well as his own perspective on the actual status quo of the environmental performance of the company's EMS of HS.

BIBLIOGRAPHY

1. ACA. (2010). HMIS® III - Questions About HMIS® and NFPA®. Retrieved June 30, 2010, from http://www.paint.org/hmis/hmis_faq3.cfm
2. Acuerdo por el que las Secretarias de Gobernación y Desarrollo Urbano y Ecología, con fundamento en lo dispuesto por los Artículos 5o. Fracción x y 146 de la Ley General del Equilibrio Ecológico y la Protección al Ambiente; 27 Fracción XXXII y 37 Fracciones XVI y XVII de la Ley Orgánica de la Administración Publica Federal, expiden el Primer Listado de Actividades Altamente Riesgosas. (1990). (p. 9). Retrieved from: http://vamosdecaceria.com/files/Primer%20listado%20de%20actividades%20altamente%20riesgosas.pdf
3. Acuerdo por el que las Secretarías de Gobernación y Desarrollo Urbano y Ecología, con fundamento en lo dispuesto por los artículos 5o.- fracción X y 146 de la Ley General del Equilibrio Ecológico y la Protección al Ambiente; 27 fracción XXXII y 37 fracciones XVI y XVII de la Ley Orgánica de la Administración Pública Federal, expiden el segundo listado de actividades altamente riesgosas. (1992). (p. 10). Retrieved from http://www.semarnat.gob.mx/gestionambiental/materialesyactividadesriesgosas/Documents/segundolaar.pdf
4. Andrews, R. N. L. (2004). Environmental regulation and business `self-regulation'. Policy Sciences, Humanities, Social Sciences and Law, 31(3), 177-197. doi:10.1023/A:1004377715029
5. Anglés-Hernández, M. (2006). Sustancias Peligrosas, Riesgo y Salud En México. Marco Normativo. In Estudios en homenaje a Marcia Muñoz de Alba Medrano, Doctrina Jurídica (Primera). Distrito Federal, México: Universidad Autónoma de México, Instituto de Investigaciones Jurídicas. Retrieved from http://www.bibliojuridica.org/libros/5/2252/7.pdf
6. ANIQ. (n.d.). Sistema Globalmente Armonizado de Comunicación y Etiquetado de Químicos (GHS siglas en Inglés o SGA en Español). Retrieved from www.aniq.org.mx/Comisiones/Docs_SH/GHS.doc
7. Baxter, M. (2007, February 16). Taking the first steps in environmental management. ISO Environmental Management Systems, (July-August 2004), 13-18.
8. Bloor, M., & Wood, F. (2006). Keywords in Qualitative Methods: A Vocabulary of Research Concepts. London; Thousand Oaks; New Delhi: Sage Publications Ltd.
9. Boiral, O., Cayer, M., & Baron, C. M. (2009). The Action Logics of Environmental Leadership: A Developmental Perspective. Journal of Business Ethics, 85(4), 479-499. doi:10.1007/s10551-008-9784-2
10. BS7750. (2006, February). . Retrieved May 14, 2010, from http://www.quality.co.uk/bs7750.htm
11. Carson, P., & Mumford, C. (2002). Hazardous Chemicals Handbook (Second.). Great Britain: Butterworth-Heinemann. Retrieved from http://www.sciencenet.cn/upload/blog/file/2009/7/20097210920856430.pdf

12. Chen, B. (2004). ISO 14001, EMAS, or BS 8555: An assessment of the Environmental Management Systems for UK businesses (Master of Science). Norwich: School of Environmental Sciences, University of East Anglia. Retrieved from http://www.uea.ac.uk/env/all/teaching/eiaams/pdf_dissertations/2004/Chen_Bo.pdf
13. Comisión de Medio Ambiente y Recursos Naturales. (2000). Sistema de Manejo Ambiental. LX Legislatura. Mexico. Retrieved from http://archivos.diputados.gob.mx/Comisiones/Ordinarias/Medio_Ambiente/powerpoint/queesunSMA.pps
14. Cortinas de Nava, C. (2000a). Comunicación de riesgos para el manejo de sustancias peligrosas, con énfasis en residuos peligrosos : Handbook. México: Instituto Nacional de Ecología. Retrieved from http://www.cristinacortinas.net/images/publicaciones/comunicacion_de_riesgos.pdf
15. Cortinas de Nava, C. (2000b). Gestión Ambiental y Sanitaria de las Sustancias Químicas o Materiales Peligrosos. Retrieved from http://www.cristinacortinas.net/images/sustancias/cursos/Gestion_Sustancias_Quimicas.ppt
16. Council of the European Economic Community. (1967). COUNCIL DIRECTIVE 67/548/EEC of 27 June 1967 on the approximation of laws, regulations and administrative provisions relating to the classification, packaging and labelling of dangerous substances (p. 3). Retrieved from http://ecb.jrc.ec.europa.eu/legislation/1967L0548EC.pdf
17. CSA Technical Committee on Environmental Management Systems. (n.d.). Summary of key changes between ISO 14001:1996 and ISO 14001:2004.
18. D.O.F. 25-XI-2008.. Retrieved from http://www.stps.gob.mx/DGSST/normatividad/noms/Nom-026.pdf
19. ECHA. (2009). Questions & Answers on Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures. Retrieved from http://echa.europa.eu/doc/classification/questions_and_answers_clp_20090526.pdf
20. EPA. (1975). DDT Regulatory History: A Brief Survey (to 1975). Retrieved June 29, 2010, from http://www.epa.gov/history/topics/ddt/02.htm
21. Erste Allgemeine Verwaltungsvorschrift zum Bundes–Immissionsschutzgesetz (Technische Anleitung zur Reinhaltung der Luft – TA Luft). (2002). (p. 239). Retrieved from http://www.bmu.de/files/pdfs/allgemein/application/pdf/taluft.pdf
22. European Commission. (2008). EMAS - Factsheet. EU Publications Office. Retrieved from http://ec.europa.eu/environment/emas/pdf/factsheet/fs_iso_en.pdf
23. European Commission. (2010 5). European Commission - Environment - Chemicals. The directive on dangerous substances. Retrieved May 25, 2010, from http://ec.europa.eu/environment/chemicals/dansub/home_en.htm
24. European Commission. (2010). EMAS. EUROPA - Environment - EMAS- Eco-Management and Audit Scheme. Retrieved June 24, 2010, from http://ec.europa.eu/environment/emas/index_en.htm
25. FAO. (1985). International Code of Conduct on the Distribution and Use of Pesticides. Retrieved June 30, 2010, from http://www.fao.org/docrep/x5562e/X5562e0a.htm

26. González-Osorio, L. M., Flores-Martínez, A., & Rodríguez-Ortega, C. E. (Eds.). (2005). Los indicadores ambientales. In Indicadores Básicos del Desempeño Ambiental de México: 2005. México. Retrieved from http://www.semarnat.gob.mx/informacionambiental/snia/Documents/pdf/Indicadores_basicos_2005.pdf
27. Group - ThyssenKrupp AG. (2009, November). . Retrieved August 1, 2010, from http://www.thyssenkrupp.com/en/konzern/index.html
28. Holbrook, J. (2009, November). Introduction to Environmental Management Systems and related Standards. Information and Advisory Note Number 46. Retrieved June 24, 2010, from http://scottishfossilcode.org/publications/on-line/advisorynotes/46/46.htm
29. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:396:0001:0849:EN:PDF
30. ISGUS GmbH. (2008). ThyssenKrupp Bilstein Suspension- ZEUS® an allen Standorten. ISGUS News, 3, 11-12.
31. Kostka, S. (1997). Umweltmanagementsysteme in der chemischen Industrie : Wege zum produktionsintegrierten Umweltschutz mit 57 Tabellen. Berlin [u.a.]: Springer.
32. Ley General de Equilibrio Ecologico y Proteccion al Ambiente. (1988). Diario Oficial de la Federación. Retrieved from http://www.conanp.gob.mx/pdf/leygra_eqilibrio.pdf
33. Ley General para la Prevención y Gestión Integral de los Residuos. (2007). Diario Oficial de la Federación (p. 42). Retrieved from http://www.cddhcu.gob.mx/LeyesBiblio/pdf/263.pdf
34. Lohani, B., Evans, J. W., Everitt, R. R., Ludwig, H., Carpenter, R. A., & Tu, S. (1997). Chapter 3: Methodology of EIA. In Environmental impact assessment for developing countries in Asia. Manila: Asian Development Bank.
35. Márquez R., F. (n.d.). Capítulo I. Productos Químicos y su toxicidad. In Manejo Seguro de Sustancias Peligrosas (pp. 1-2). Chile: Departamento de Ingeniería Química. Retrieved from http://www.udec.cl/matpel/cursos/sustancias_peligrosas.pdf
36. Misión Permanente de México. (2008). Comments from Mexico.
37. NSF-International Registrations, LTD. (2009, March). Internal Audit Checklists | Environmental Management System. Retrieved from http://www.sandiego.gov/environmental-services/ems/audit_lists.shtml
38. PROFEPA. (n.d.). Guía de Auto-evaluación Ambiental. Retrieved from http://www.profepa.gob.mx/PROFEPA/AuditoriaAmbiental/ProgramaNacionaldeAuditoriaAmbiental/
39. Rajvanshi, A. (2006). Methodologies for ecological baselines and prediction of impacts on biodiversity resources. Presented at the IAIA '06 Pre-meeting training course, Stavanger, Norway. Retrieved from http://people.exeter.ac.uk/rwfm201/cbbia/downloads/Stav06/6methodologies.pdf
40. Rattner, B. A. (2009). History of wildlife toxicology. Ecotoxicology, 18, 773-783. doi:10.1007/s10646-009-0354-x
41. REACH. (2006). (p. 849). Retrieved from:
42. Rotterdam Convention Secretariat. (1998). Rotterdam Convention • Share Responsibility. Retrieved June 30, 2010, from http://www.pic.int/home.php?type=t&id=5&sid=16

43. Schulz, E. D. (n.d.). ThyssenKrupp Environmental Guidelines. Retrieved from http://www.thyssenkrupp-technologies.com/documents/engagement/Environmental_Guidelines.pdf
44. SCT. (2009). Especificaciones especiales y de compatibilidad para el almacenamiento y transporte de las substancias, materiales y residuos peligrosos de la clase 1 explosivos. Ley Orgánica de la Administración Pública Federal. Retrieved from http://www.dof.gob.mx/documentos/3964/sct/sct.htm
45. Secretariat of the Stockholm Convention. (2008). Stockholm Convention on Persistent Organic Pollutants. Retrieved June 30, 2010, from http://chm.pops.int/Home/tabid/36/language/es-CO/Default.aspx
46. Serrano, J. C., & Sánchez, Y. A. (2005). ANALISIS TEÓRICO DE LA COMBUSTIÓN EN QUEMADORES DE GAS NATURAL. Scientia et Technica Año XI, No. 29, 139-143.
47. Spedding, L., Jones, D., & Dering, C. (1993). ECO-management and ECO-auditing: environmental issues in business. London ;New York: Chancery Law Pub.
48. Stapleton, P. J., & Glover, M. A. (2001). Environmental Management Systems: An Implementation Guide for Small and Medium-Sized Organizations. NSF International. Retrieved from http://www.epa.gov/owm/iso14001/ems2001final.pdf
49. STPS. (1999). NOM-005-STPS-1998, Relativa a las condiciones de seguridad e higiene en los centros de trabajo para el manejo, transporte y almacenamiento de sustancias químicas peligrosas. D.O.F. 2-II-1999.. Retrieved from http://www.stps.gob.mx/DGSST/normatividad/noms/Nom-005.pdf
50. STPS. (2000a). NOM-010-STPS-1999, Condiciones de seguridad e higiene en los centros de trabajo donde se manejen, transporten, procesen o almacenen sustancias químicas capaces de generar contaminación en el medio ambiente laboral. D.O.F. 13-III-2000. (aclaración y fe de erratas D.O.F. 21-VIII-2000).. Retrieved from http://www.stps.gob.mx/DGSST/normatividad/noms/Nom-010.pdf
51. STPS. (2000b). NOM-018-STPS-2000, Sistema para la identificación y comunicación de peligros y riesgos por sustancias químicas peligrosas en los centros de trabajo. D.O.F. 27-X-2000. (aclaración D.O.F. 2-I-2001). Retrieved from http://www.stps.gob.mx/marcojuridico/Nom-018.pdf
52. STPS. (2001). NOM-006-STPS-2000, Manejo y almacenamiento de materiales - Condiciones y procedimientos de seguridad. D.O.F. 9-III-2001.. Retrieved from http://www.stps.gob.mx/DGSST/normatividad/noms/Nom-006.pdf
53. STPS. (2008a). NOM-026-STPS-2008, Colores y señales de seguridad e higiene, e identificación de riesgos por fluidos conducidos en tuberías.
54. STPS. (2008b). NOM-025-STPS-2008, Condiciones de iluminación en los centros de trabajo. D.O.F. 20-XII-2008. Retrieved from http://www.stps.gob.mx/DGSST/normatividad/noms/Nom-025.pdf
55. STPS. (2008c). NOM-028-STPS-2005, Organización del Trabajo-Seguridad en los Procesos de sustancias químicas. D.O.F. 14-I-2005.. Retrieved from http://www.stps.gob.mx/DGSST/normatividad/noms/Nom-028.pdf

56. STPS. (2008d). NOM-017-STPS-2008, Equipo de protección personal - Selección, uso y manejo en los centros de trabajo. D.O.F. 9-XII-2008.. Retrieved from http://www.stps.gob.mx/DGSST/normatividad/noms/Nom-017.pdf
57. Tchobanoglous, G., & Metcalf & Eddy. (2008). Wastewater engineering : treatment and reuse (4º ed.). Boston [Mass.] ;;London: McGraw-Hill.
58. The Precautionary Principle. (2005). . World Commission on the Ethics of Scientific Knowledge and Technology (COMEST). Retrieved from http://unesdoc.unesco.org/images/0013/001395/139578e.pdf
59. ThyssenKrupp AG ©. (2009, September 29). Detail view - Locations - ThyssenKrupp AG. Retrieved June 16, 2010, from http://www.thyssen.com/en/standorte/detail.html&orga_id=801213
60. ThyssenKrupp Bilstein Sasa. (2008, March 1). POLÍTICA AMBIENTAL.
61. ThyssenKrupp Bilstein Suspension GmbH. (2009, June). Management Handbuch.
62. TÜV NORD CERT GmbH. (2009, November 12). DIN EN ISO 14001:2005 Certificate. Retrieved from http://www.thyssenkrupp-bilstein.de/fileadmin/pdfs/publikationen/umwelt/091471-003_ThyssenKrupp_Bilstein_Suspension_Werk_Oege_UM_WA_09_Fli_en.pdf
63. Umweltmanagementsysteme –Anforderungen mit Anleitung zur Anwendung (ISO 14001:2004 + Cor 1:2009)Deutsche und Englische Fassung EN ISO 14001:2004 + AC:2009. (2009). .
64. UNECE, (n.d.). CRTD - Convention on Civil Liability for Damage Cause during Carriage of Dangerous Goods by Road, Rail and Inland Navigation Vessels. Retrieved June 30, 2010, from http://www.unece.org/trans/danger/publi/crtd/crtd_e.html
65. UNECE. (1992). Convention on the Transboundary Effects of Industrial Accidents. Retrieved June 30, 2010, from http://www.unece.org/env/teia/
66. UNECE. (2000). ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways. Retrieved June 30, 2010, from http://www.unece.org/trans/danger/publi/adn/adn_e.html
67. UNECE. (2009). European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR). Retrieved June 30, 2010, from http://www.unece.org/trans/danger/publi/adr/adr_e.html
68. UNECE. (2010). Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Retrieved June 30, 2010, from http://www.unece.org/trans/danger/publi/ghs/ghs_welcome_e.html
69. UNEP, (n.d.). Stockholm 1972 - Declaration of the United Nations Conference on the Human Environment. Retrieved May 18, 2010, from http://www.unep.org/Documents.Multilingual/Default.asp?documentid=97&articleid=1503
70. UNEP. (1972). Stockholm 1972 - Declaration of the United Nations Conference on the Human Environment. Retrieved June 30, 2010, from http://www.unep.org/Documents.Multilingual/Default.asp?documentid=97&articleid=1503
71. Verordnung über Anforderungen an das Einleiten von Abwasser in Gewässer or Abwasserverordnung. (1997). . Retrieved from http://www.gesetze-im-internet.de/abwv/anhang_40_44.html

72. Verordnung zum Schutz vor Gefahrstoffen (Gefahrstoffverordnung - GefStoffV). (2004). . Retrieved from http://www.gesetze-im-internet.de/gefstoffv_2005/
73. WCED. (1987). Chapter 2: Towards Sustainable Development. In Our common future (Oxford University Press.). Oxford ; New York: Oxford University Press. Retrieved from http://www.un-documents.net/ocf-02.htm#I
74. Wenk, M. S. (2005). Interrelationships between BS 7750 and the EMAS Program. In The European Union's Eco-Management and Audit Scheme (EMAS), ECO-Efficiency in Industry and Science (Vol. 16, pp. 5-8). Springer Netherlands.
75. West, J. (2003). Pesticides and Polio: Graphic documentation regarding epidemiology and physiology of polio. Images Of Poliomyelitis: A Critique Of Scientific Literature, . Retrieved June 29, 2010, from http://www.harpub.co.cc/overview.htm
76. WHO. (2007). Chapter 2. Threats to public health security. In Overview. The World Health Report 2007. A safer future (pp. 16-33). Retrieved from http://www.who.int/whr/2007/07_overview_en.pdf
77. Yarnell, P. (1999). Implementing an ISO 14001 Environmental Management System. A Case Study of Environmental Training and Awareness at the Vancouver International Airport Authority (Master of Natural Resources Management). School of Resource and Environmental Management, University of Manitoba. Retrieved from http://research.rem.sfu.ca/theses/yarnell.pdf

APPENDIXES

A.1. Document HSA.1 - Hazardous Substances Analysis – Process description

A.2. Document HSA.2 - Hazardous Substances Analysis – Safety Data Sheet Analysis

A.3. Document VI.1 - Visual Inspection of Hazardous Substances Management Stages (HS-MS)

A.4. Document EMS.1 - Environmental Management System Revision

A.5. Document PM.1 - Process Managers Interview

A.6. Document WI.1 - Workers Interview

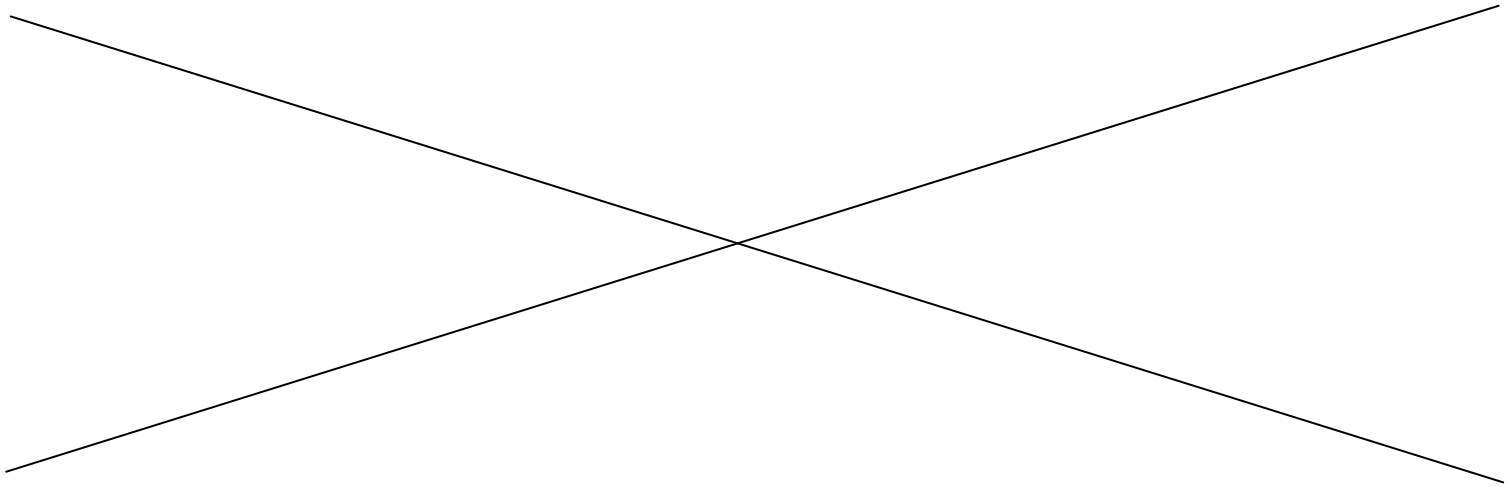
A.7. Document ROA.1 - Results and Opportunity Areas

A.8. Matrix of Environmental Behaviours o Elements of Evaluation

DOCUMENT HSA.1			
REVISION STAGE:	**Hazardous Substances Analysis** – Process description	***Date (dd.mm.yyyy):*** ____.____._____	***Page*** __ ***of*** __
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

PROCESS:	

(Draw or scheme of process of interest)



COMMENTS:

ROWS AND COLORS DESCRIPTION	**SYMBOLS DESCRIPTION**

DOCUMENT HSA.2			
REVISION STAGE:	**Hazardous Substances Analysis** – Safety Data Sheet Analysis	***Date (dd.mm.yyyy):*** ____.____._____	***Page*** __ ***of*** __
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

Process	**Subst. No.**	**Elements of revision** / **Substances**	**Storage quantities**	**MSDS Data**					**Is it HS? Y/N**
				General Content	**Hazard Identification** *According to GHS*	**Relevance** *(meaning of code)*	**Temp. (°C)** **(storage / use)**	**Notes**	

NO./PROCESS(ES): *e.g. 1/Washing*	***COMMENTS:***

DOCUMENT VI.1			
REVISION STAGE:	**Visual Inspection of Hazardous Substances Management Stages (HS-MS)**	***Date** (dd.mm.yyyy):* ____.____._____	***Page** 1 of 2*
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

HS-MS	Instruction		EVAL. CODE	PROCESSES No. → / SUBSTANCES No. → / Element of evaluation	Categories: P1. Process 1				P2. Process 2		
					1	2	3	4	5	6	7
					A Substance	B Substance	C Substance	D Substance	E Substance	F Substance	G Substance
I. PRE-STORAGE	Describe the following storage conditions: ***D** - Inadequate* ***C / B -** Legally acceptable* ***A** - Proved adequate / Prevention of future scenarios of increase quantities*	Each substance	4.2	**E1.** State of containers							
				E2. Containers Labeling							
				E3. Distance and location of containers from each other							
		Storage site	4.1	**E4.** Safety Data Sheets							
				E5. Safety Management and Hygiene Program		***COMMENTS:***					
			4.3	**E6.** Cool and dry							
				E7. Ventilation							
				E8. Absence of heat and sunlight							
				E9. Emergency signalization							

HS-MS	EVAL. CODE	Revision per Hazardous Substance *(Substances # as indicated in Pre-storage stage)*	Categories: 1	2	3	4	5	6	7
II. USE	5.5	**E10.** *Is the substance being recovered or reused?* ***C-** Not at all; **B-** Partially; **A-** Completely recovered and recycled* ***COMMENTS:***							

EVAL. CODE	Revision per Process *(Processes # as indicated in Pre-storage stage)*			Categories: P1	P2	P3
3.4	**E11.** *Are workers exposed to the substances:* ***D-**Unknown; **C-** Acceptable according to legal authorized limits; **B-** According to SDS recommendations; **A-** Not exposed* ***COMMENTS:***					
3.3	**E12.** *Indicate the number of the Personal Protective Equipment (PPE) identified in each process:* ***1. Security glasses*** ***2. Gloves** (comment if special)* ***3. Ear protection*** ***4. Security shoes*** ***5. Security hat*** ***6. Other** (explain)*	**P1:** **P2:** **P3:**	*Categories:* ***D-**Not identified;* ***C / B-** Acceptable according to legal authorized limits;* ***A-** Acceptable according to SDS recommendations.*			
4.4	**E13.** *Indicate the number of the elements identified in the equipment and machinery used in each process:* ***1. Operator registry*** ***2. Operation indications*** ***3. Hazard Signalization*** ***4. Maintenance frequency registry*** ***5. Other** (explain)*	**P1:** **P2:** **P3:**	*Categories:* ***D-**Not identified;* ***C / B-** Acceptable according to legal authorized limits;* ***A-** Acceptable according to SDS recommendations.*			
	COMMENTS:					

DOCUMENT VI.1			
REVISION STAGE:	**Visual Inspection of Hazardous Substances Management Stages (HS-MS)**	***Date** (dd.mm.yyyy):* ____.____._____	***Page** 2 of 2*
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

HS-MS	EVAL. CODE	Question / Substance	Categories 1	2	3	4	5	6	7
III. WASTE MANAGEMENT	6.2	**E14.** *What is the WASTE GENERATED when the substance (#) has been used?* ***COMMENTS:***							
		Identification method to determine hazard level: ***D-** Not identified**; C-** Empirical; **B-** Supported analysis by authorized laboratory*							
	6.2	**E15.** *Is the substance's waste included on company's waste treatment?* ***D-** Non-included; **C-** Partially; **B-** Totally; **A-** No waste generation* ***COMMENTS:***							
	6.3	**E16.** *What kind of technology is used for the treatment of substance (#)?* ***D -** No treatment; **C -** Only physical; **B -** Physical, chemical and/or biochemical; **A-** Classified as clean technology* ***COMMENTS:***							
		COMMENTS:							

HS-MS	Instruction	EVAL. CODE	Element of evaluation / Substance	Categories 1	2	3	4	5	6	7
IV. WASTE STORAGE	Describe the following storage conditions: ***D** - Inadequate* ***C / B** - Legally acceptable* ***A**- Proved adequate / Prevention of future scenarios of increase quantities*	8.2	**E17.** State of containers							
			E18. Containers Labeling							
			E19. Distance and location of containers from each other							
		8.3	**E20.** Cool and dry		***COMMENTS:***					
			E21. Ventilation							
			E22. Absence of heat and sunlight							
			E23. Warning and Restriction Signalization							
		8.1	**E24.** Registry of quantities storage and sent							
			E25. Safety Management and Hygiene Program							

EVAL. CODE	Question	Category
8.4	**E26.** *How much time is generated waste storage before been sent to treatment?* ***D-** Uncontrolled (>6 months)**; C / B -** 6 months or less (adaptable to what is legally authorized); **A-** Sent before represent risk that cannot be controlled* ***COMMENTS:***	

	EVAL. CODE	*Indicate the number of the emergency measures and infrastructure identified in the different hazardous substances management stages (HS-MS).* *Categories: **D**-Not identified**; C / B -** Acceptable according to legal authorized limits; **A-** Prevent future scenarios*		Categories I. E27.	II. E28.	III. E29.	IV. E30.
V. EMERGENCY MEASURES	4.3 4.6 8.3	***1. Fire extinguisher*** ***2. Showers*** ***3. Emergency sewage*** ***4. Eye washers*** ***5. Canalization*** ***6. Others** (explain)*	**I:** **II:** **III:** **IV:**				

DOCUMENT EMS.1			
REVISION STAGE:	**Environmental Management System Revision**	***Date** (dd.mm.yyyy):* _____._____._____	***Page 1 of 3***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

EVAL. CODE	**PART A. DOCUMENT REVISION OF EMS**	
1.1	**E1.** *Environmental Policy (EP) or commitment statement.* *The analysis of the statement indicates: **C**-Legal compliance, **B** - Pollution prevention or mitigation, **A**- Sustainability, precaution and continual improvement.*	
1.1	**E2.** *Environmental policy scope is oriented to:* ***C**-Meet legal requirements on environment and occupational safety , **B**-Influence on adapt processes and materials, **A**-Managers (decision makers)*	
1.2	**E3.** *Level of structure and organization on EMS* ***Structure: C**-Only legal records, **B**-Defined structure based environmental management guidelines , **A**-Integration of different management guidelines* ***Organization: C**-responsibility lays on only one legal representative, **B**-established structure indicating roles and obligations, **A**- proved sufficiency and efficiency on the developed Env. department*	
1.3 **1.7**	**E4.** *Sustainability elements on established environmental objectives and targets* ***C** –Production, incomes and legal framework compliance, **B** – Environmental protection and impact diminution , **A** – Public determined from stakeholder analysis*	
1.4	**E5.** *Sectors of evaluation taken into account in environmental objectives and targets:* ***C** – only those including legal framework, **B** –aspects considered in adopted guidelines (ISO 14001,OHSAS,EMAS), **A** – All sectors have sustainability and precautionary orientation*	
1.5	**E6.** *Actors involved in EMS fundaments commitment:* ***C** – Managers and local authorities, **B** – Workers and process managers, **A** – Public determined from stakeholder analysis*	

*Notes: * **D** means: No information available / The element does not exist / or specified ; ** Combinations must mark which, e.g. A+B..)*

Comments:

DOCUMENT EMS.1			
REVISION STAGE:	**Environmental Management System Revision**	***Date** (dd.mm.yyyy):* ____.____._____	***Page 2 of 3***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

PART B – EMS INTERVIEW WITH ENVIRONMENTAL ISSUES RESPONSIBLE

INTERVIEWEE:	

EVAL. CODE	Question	Category
1.6	**Q1.** *How do you promote community's involvement in your decisions making processes?* ***C** - Partially informed, **B** - Complete info. Available, No third parties involvement, **A**- Info. Available, diffused and promoted; third parties involved* ***ANSWER:***	
1.7	**Q2.** *According to the company's environmental goals, how do you evaluate the achievement of objectives and goals?* ***C** – no planning, **B** – plans establish how to check each objective progress, **A**- plans as in level B but marking objectives interrelation.* ***ANSWER:***	
1.8	**Q3.** *Which indicators do you use to evaluate the company's performance at some of these issues?* Emergency preparedness: _____ Chemicals acquisition: _____ Chemicals consumption: _____ Waste generation: _____ Waste treated: _____ Waste disposal: ***C**- Increase production and profits, revision of established parameters by authorities;* ***B**- First level self-developed indicators;* ***A**- Self-developed indicators of third level*	
5.4 **5.6**	**Q4.** *Could you order the following elements as priorities for the company in order to guide environmental improvements?* (__) Input materials substitution (__) Technology changes in the processes (__) Change to better waste treatment technologies Others: *Levels 1, 2, 3…*	
1.9	**Q5.** *What is the driving force that guides the introduction of those changes in the company's processes?* ***D**- Clients; **C** – Clients and legal requirements, **B** – Market opportunities and Env. impact mitigation, **A**- Continuous improvement in environmental management, sustainability and responsible care recognition.* ***ANSWER:***	
1.10	**Q6.** *How often are the Environmental goals revised and redefined?* ***C** – As government request, **B** – Only internal audits but not frequency established, **A**- Internal and external audits planned and scheduled* ***ANSWER:***	

*Notes: * **D** means: No information available / The element does not exist / or specified ; ** Combinations must mark which, e.g. A+B..)*

Comments:

DOCUMENT EMS.1			
REVISION STAGE:	**Environmental Management System Revision**	***Date** (dd.mm.yyyy):* ____.____._____	***Page 3 of 3***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

PART C - INTERVIEW WITH ENVIRONMENTAL ISSUES RESPONSIBLE		
INTERVIEWEE:		
In this part of the interview categories shall be given directly from the analysis of the answer and its comparison with the environmental behaviours in the ***Matrix of environmental behaviours on elements of revision.***		
EVAL. CODE	**Question**	**Category**
2.1 **2.2** **2.3**	**Q7.** *What do you consider to be the prime difficulty when integrating environmental goals with production efficiency? How do you reconcile those problems?* ***ANSWER:***	
2.2 **2.3**	**Q8.** *Referring to public concern, how does the company take public expectations and participation into consideration when referring to environmental issues?* ***ANSWER:***	
2.4	**Q9.** *How has environmental goals influenced the company's production practices?* ***ANSWER:***	

Comments:

DOCUMENT PM.1			
REVISION STAGE:	**Process Managers Interview**	***Date** (dd.mm.yyyy):* _____._____._____	***Page 1 of 2***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

PART A. HAZARDOUS SUBSTANCES AND PROCESSES INFORMATION.

EVAL. CODE	PROCESSES / Hazardous Substances / Question	Categories: P1. Process 1 – Substance A	P1. Process 1 – Substance B	P1. Process 1 – Substance C	P1. Process 1 – Substance D	P2. Process 2 – Substance E	P2. Process 2 – Substance F	P3. Process 3 – Substance G	P3. Process 3 – Substance H
5.1	**Q1.** *What kind of requirement is asked to the supplier company referring to the chemical product production?* ***D**- None; **C**- Legally approved supplier; **B**- Management quality certification; **A**- Responsible Care® or similar certification* ***ANSWER:***								
5.2	**Q2.** *Do you consider that the quantities on which each substance is used represent a risk for the worker and/or environment safety?* ***D**- Unknown / Quantities represent risk; **C** - Legally not considered / Quantities below risk; **B** - Internationally no risk consider / Quantities below risk; **A** - Analysis prove no risk / Quantities below risk* ***ANSWER:***								
5.4	**Q3.** *Can the substance be replaced by one less hazard?* ***D**- Unknown; **C**- No research, but other factors point this as best; **B**- Proved of research, but no yet possible; **A** - Replaced less than 5 years ago* ***ANSWER:***								
5.6 6.4 6.5	**Q4.** *Do actual existing green technologies have any impact on each process?* ***D** – No research done yet; **C** - End-of-pipe tech. to reduce environmental impact; **B** - In-line tech. to reduce waste generation and materials recovery; **A** - Green tech. has already been introduced* ***ANSWER:*** **P1:** **P2:** **P3:**								

PART B. ENVIRONMENTAL PERFORMANCE PERCEPTION

EVAL. CODE	Question	Category
6.1 6.5	**Q5.** *What is the quality of the discharge values? Is this technology ?* ***D** - Unknown – no revision; **C** – Acceptable, no legal breaches; **B**- Good, below water quality international parameters; **A**- No wastewater generation* ***ANSWER:***	
7.1	**Q6.** *What is the hazard level of resulted waste?* ***D**- Unknown; **C**- Hazard based on national guidelines; **B** - Hazard based on international guidelines; **A** - Proved non-hazard* ***ANSWER:***	

DOCUMENT PM.1			
REVISION STAGE:	**Process Managers Interview**	***Date** (dd.mm.yyyy):* _____._____._____	***Page*** ***2 of 2***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

EVAL. CODE	Question	Category
7.4	**Q7.** *Had the hazard level of generated waste changed over time in the past 10 years?* ***D****- Unknown / Has not changed;* ***C*** *- Yes, just below national guidelines;* ***B****- Yes, just below international guidelines (specify guidelines);* ***A****- Proved non-hazard* ***ANSWER:***	
7.2	**Q8.** *From 1 year ago, the ratio production/hazardous waste generation has been:* ***D****- Increased;* ***C****- Maintained;* ***B****- Reduced;* ***A****- Avoid* ***ANSWER:***	
7.3	**Q9.** *From 1 year ago, the ratio of production/atmospheric emissions has been:* ***D****- Increased;* ***C****- Maintained;* ***B****- Reduced;* ***A****- Avoid* ***ANSWER:***	
8.4	**Q10.** *Are temporal hazardous waste containers cleaned or replaced?* ***D****- Particulars reused, or no revision of conditions;* ***C*** *– Particular containers are replaced after sent; large industrial are not replace nor maintained just emptied;* ***B****- As level C , plus physical resistance verification of the industrial ones;* ***A****- As in B, but industrial are cleaned/maintained to prevent risk (replace if necessary)* ***ANSWER:***	
9.2	**Q11.** *Do you verify the safe transportation of the Hazardous waste when collected by other companies? How?* ***D****- Not conditions verification;* ***C*** *or* ***B****- Yes, documents verification from the provider company;* ***A****- Yes, documents verification and self vehicle conditions revision* ***ANSWER:***	
9.1	**Q12.** *After waste is collected, do you know what its final destiny is?* ***D****- Unknown/Unsafe/Inappropriate;* ***C*** *– Incineration;* ***B****- Deposition by a certified company;* ***A*** *- Treated, recycled or reused by other companies* ***ANSWER:***	
9.4	**Q13.** *When deposition is required, do you know the final confinement site?* ***D****- Unknown;* ***C****- Yes, but no more information of the site;* ***B*** *- Yes, information of site and documented as safe; A- waste is not confined, but recycled or reused.* ***ANSWER:***	

Comments:

DOCUMENT WI.1			
REVISION STAGE:	**Workers Interview**	***Date** (dd.mm.yyyy):* _____._____._____	***Page*** ***1 of 2***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

PART A. HS SUBSTANCES AND PROCESSES INFORMATION.

EVAL. CODE	PROCESS / Hazardous Substances / Questions / Hazard Identification *(use information from **HSA.2**)* →	Categories: Process 1 – Substance A	Process 1 – Substance B	Process 1 – Substance C	Process 1 – Substance D	Process 2 – Substance E	Process 2 – Substance F	Process 3 – Substance G	Process 3 – Substance H
3.2	**Q1.** *Could you recognize some hazardous substances in the process?* *Mark the ones mentioned with "✓"* ***Others /Comments:***								
3.2	**Q2.** *Can you mention some adequate pre-storage conditions for these hazardous substances? If so, why are they important?* ***D**- No measures identified, **C**-Only general, no reasons identified, **B** – General and specific, no reasons identified, **A** – General and specific, reasons identified* ***GENERAL CONDITIONS (For all substances in general)*** ***SPECIAL CONDITIONS (For specific substances in general):***								
3.2 **3.5**	**Q3.** *Do you know any special emergency measure in case of spill, leakage or escape of any of these substances? If so, how did you know it?* ***D**- No measures identified, **C**-Immediate attention known from experience or common sense, **B**- As C + emergency communication, known from training program, **A**- As B + known from training programs and plant visual emergency signalization..* ***ANSWER:***								
3.3	**Q4.** *Which personal protection equipment do you need to use in the different areas of labour?* ***D**- Unknown, **C**-Required equipment Immediate attention known from experience or common sense, **B**- As C + emergency communication, known from training program, **A**- As B + known from training programs and plant visual emergency signalization.* ***ANSWER:***								

PART B. ENVIRONMENTAL PERFORMANCE PERCEPTION

In this part of the interview categories shall be given directly from the analysis of the answer and its comparison with the environmental behaviours in the ***Matrix of environmental behaviours on elements of revision.***

EVAL. CODE	Question	Category
3.1	**Q5.** *What green elements would you identify in the company's practices?* ***ANSWER:***	
3.4	**Q6.** *How much time do you spend in these line processes? Is there worker rotation between processes?* ***ANSWER:***	

DOCUMENT WI.1			
REVISION STAGE:	**Workers Interview**	***Date** (dd.mm.yyyy):* ____.____._____	***Page*** ***2 of 2***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			
SUPERVISOR:			

In this part of the interview categories shall be given directly from the analysis of the answer and its comparison with the environmental behaviours in the ***Matrix of environmental behaviours on elements of revision.***

EVAL. CODE	Question	Category
3.5	**Q7.** *Who would you call for assistance in an chemical contingency?* ***ANSWER:***	
3.6	**Q8.** *Does the company promotes the ideas and experiences sharing in order to improve processes environmental performance?* ***ANSWER:***	
3.7	**Q9.** *When was your last emergency training program against chemical accidents?* ***ANSWER:***	

Comments:

DOCUMENT ROA.1			
REVISION STAGE:	**Results and Opportunity Areas**	***Date (dd.mm.yyyy):*** ____.____._____	***Page 1 of __***
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			

PART I. RESULTS RESUME

SECTOR	EVAL. CODE	ELEMENT OF EVALUATION	ENVIRONMENTAL BEHAVIOUR (EB)			
			D	C	B	A
1. COMPANY'S EMS BASES AND PRINCIPLES	1.1	Environmental policy scope				
	1.2	Level of structure and organization on EMS				
	1.3	Sustainability targets and levels				
	1.4	Develop and improvement targets and levels				
	1.5	Required commitments to authorities, environment , and public				
	1.6	Public participation and informing				
	1.7	Linking level of objectives and planning				
	1.8	Environmental Indicators level				
	1.9	Motivations of improvement				
	1.10	Frequency of revision and replanting environmental objectives				
2. HEAD MANAGERS	2.1	Capability of dealing with the complexity of environmental issues				
	2.2	Integration level of seemingly contradictory outlooks				
	2.3	Capability of understanding and addressing expectations of stakeholders				
	2.4	Capabilities of adaptability and organizational practices change				
3. WORKERS I NVOLVEMENT	3.1	Awareness on environmental company's policy				
	3.2	Risk Awareness – Identify of HS during process and adequate handling knowledge				
	3.3	Level on Safety equipment use and surveillance				
	3.4	Frequency of exposure				
	3.5	Risk Communication level				
	3.6	Inclusion of workers comments, ideas or experiences to improve environmental performance.				
	3.7	Training emergency programs				
4. OCCUPATIONAL HEALTH AND SAFETY – STORAGE AND USE OF HS	4.1	Planning and registry control on the storage of HS				
	4.2	Containers of input hazardous materials status				
	4.3	Safety site measures in the storage of HS				
	4.4	Planning and registry control on the use of HS				
	4.5	Worker's protection measures in the use of HS				
	4.6	Safety site measures in the use of HS				
5. HS AS INPUT MATERIALS	5.1	Responsible care from suppliers				
	5.2	Awareness level on the HS quantities used in the company and about the risk they represent.				
	5.3	Actual number of HS substances that the company use, including level of hazard				
	5.4	Research level on replacement of HS in the process				
	5.5	Level of recovering and recycling materials.				
	5.6	Research and Introduction of "clean technologies" in the processes				
6. HS WASTE TREATMENT	6.1	Water discharge limits compliance				
	6.2	Extension of HS-waste treated in the company				
	6.3	Process potential environmental impact				
	6.4	Research and Introduction of "clean technologies" in the process				
	6.5	Technology performance on discharge quality values				
7. HS AS FINAL COMPANY'S GENERATED WASTE	7.1	Final hazard level of obtained waste after treatment.				
	7.2	Waste generation vs. production ratio over time.				
	7.3	Emissions generation vs. production ratio over time.				
	7.4	Hazard level of generated waste over time				
8. OCCUPATIONAL HEALTH AND SAFETY – HW STORAGE	8.1	Planning and registry control on the storage of HW				
	8.2	HW containers status				
	8.3	Safety site measures in the storage of HW				
	8.4	Adequate and safe HW temporal storage time and maintenance				
9. HW FINAL DESTINY – KNOWLEDGE AND VERIFICATION LEVEL	9.1	Following stages of the generated waste.				
	9.2	Hazardous waste safe transportation.				
	9.3	Waste treatment previous confinment				
	9.4	Waste final destination location.				

DOCUMENT ROA.1			
REVISION STAGE:	**Results and Opportunity Areas**	***Date (dd.mm.yyyy):*** ____.____.______	***Page*** __ ***of*** __
EVALUATOR:		***Signature:***	
COMPANY NAME:			
PLANT LOCATION:			

PART II. OPPORTUNITY AREAS IDENTIFICATION

INSTRUCTIONS: Fill the blocks on the left table according to the environmental behavior graded for each element of evaluation in the corresponding checklists. Then, after the comparative analysis with the company's environmental priorities, identify possible opportunity areas and write them down in this table. *NOTE: If exceed the spaces in this form, use other copy of this document.*

No.	EVAL. CODE	EB OBTAINED	COMMENTS:

Appendix A.8

MATRIX OF ENVIRONMENTAL BEHAVIOURS O ELEMENTS OF EVALUATION

This appendix presents an elaborated matrix that shall be used to determine categories of each element and sector of evaluation in the proposed evaluation method of this research.

Description for its use and recommendations are included in Chapter V *(see section 5.5.2)*.

List of abbreviations found in the following tables in alphabetical order:

EB	Environmental Behaviour
EMAS	Eco Management and Audit Scheme
EMS	Environmental Management System
EP	Environmental Policy statement
EVAL. CODE	Evaluation Code
HS	Hazardous Substances
HW	Hazardous Waste
ISO 14001	International Standard ISO14001:2004
PPE	Personal Protective Equipment
***Q/E ID.**	Question or Element Identification
SDS	Safety Data Sheets
WHO	World Health Organization

*The column "**Q/E ID.**" indicates the location of the question(s) or element(s) of revision in the corresponding checklists, to be used for categorizing each element of evaluation.
Documents *(checklists)* abbreviations are:

EMS.1	Environmental Management System Revision
HSA.1	Hazardous Substances Analysis – Process description
HSA.2	Hazardous Substances Analysis – Safety Data Sheet Analysis
PM.1	Process Managers Interview
VI.1	Visual Inspection of Hazardous Substances Management Stages (HS-MS)
WI.1	Workers Interview

MATRIX OF ENVIRONMENTAL BEHAVIOURS ON ELEMENTS OF REVISION.							Page 1 of 7
		Levels of performance / Environmental behaviour →		Environmentally inadequate	Environmental legally accepted	Environmentally Active	Environmentally Proactive
SECTOR	**EVAL. CODE**	**Elements of revision**	**Q/E ID.**	**D**	**C**	**B**	**A**
1. COMPANY'S EMS BASES AND PRINCIPLES	**1.1**	**Environmental policy (EP) orientation**	*EMS.1 E1, E2*	*Not documented*	*Documented and published but only refers to legal obligation awareness and compliance.*	*Documented and published. Establish awareness on legal obligations, and states compromise to prevent or mitigate environment deterioration. Moreover, states openness to processes and materials adaptations to reach this.*	*The same as level B, but includes workers and public involvement on the pursuit of a sustainable practice and responsible care. At the same establishes managers' commitment and openness to communication.*
	1.2	**Level of structure and organization on EMS**	*EMS.1 E3*	*No structure or clear distribution of responsibilities*	*Only legal requirements records, whose responsibility lays only in one company's manager / representative.*	*Document with defined structure, possibly certified based on environmental management guidelines. Includes an established structure indicating roles and obligations of processes and other departments managers involved in and environmental issues.*	*Documented, defined structure, and certified based on the integration of international guidelines on environmental and occupational health and safety management as well as responsible care. It is proved sufficiency and efficiency on the responsibilities and obligations among the managers involved with the Env. Dept.*
	1.3	**Sustainability elements in targets and objectives**	*EMS.1 E4*	*Not applicable*	*Production, incomes and legal framework compliance*	*Environmental protection and impact diminution*	*Public determined from stakeholder analysis*
	1.4	**Sectors of evaluation influenced by the EP**	*EMS.1 E5*	*Not applicable*	*Only those including legal requirements*	*Only those sectors considered in management guidelines (e.g., ISO14001, EMAS)*	*All sectors have orientation on concepts of sustainability, precautionary principle and continuous improvement.*
	1.5	**Actors involved in established commitments**	*EMS.1 E6*	*Not applicable*	*Managers and local authorities*	*Workers and process managers*	*Stakeholder analysis to determine third-party groups to involve (e.g., public, workers)*
	1.6	**Public participation and informing**	*EMS.1 Q1*	*None*	*Partially informed*	*Complete information available and published to the public. Not necessarily promoted or diffused.*	*Information as in level B but with diffusion and promotion; third-party groups' involvement.*
	1.7	**Linking level of objectives and planning**	*EMS.1 E4, Q2*	*Not applicable (No objectives established)*	*Revision but no clear link with planning (if exist).*	*Existence of established plans to check achievement of each objective.*	*Plans to check achievement of each objective consider and describe influence among objectives.*
	1.8	**Level of Environmental Indicators**	*EMS.1 Q3*	*No revision*	*Through increase on production and profits, as well as revision of established parameters by authorities.*	*Through first level self-developed indicators. Only one area of assessment, not necessarily interconnected.*	*Self-developed indicators of third level. Integrating impact from interrelated sectors.*
	1.9	**Motivations of improvement**	*EMS.1 Q5*	*Clients satisfaction Economic growth*	*As in level D, but considering legal compliance.*	*As in level C, but in pursuit of international market opportunities and considering environmental impact mitigation.*	*As in level B but with actual continuous improvement and pursuit of recognition on sustainability and environmental responsibility.*
	1.10	**Frequency of revision and replanting environmental objectives**	*EMS.1 Q6*	*Not applicable*	*Fix to government request.*	*Only internal audits but not frequency established in the EMS planning. Mostly done before certification expires.*	*Internal and external audits planned and scheduled in EMS document. Minimum frequency of 3 years (EMAS, 2008). If more EB falls in B.*

MATRIX OF ENVIRONMENTAL BEHAVIOURS ON ELEMENTS OF REVISION.							Page 2 of 7
Levels of performance / Environmental behaviour →				Environmentally inadequate	Environmental legally accepted	Environmentally Active	Environmentally Proactive
SECTOR	**EVAL. CODE**	**Elements of revision**	**Q/E ID.**	**D**	**C**	**B**	**A**
2. HEAD MANAGERS	**2.1**	**Capability of dealing with the complexity of environmental issues**	*EMS.1 Q7*	*No environmental issues are noticed*	*No complex issues are noticed, since environmental targets are specified by law.*	*Able to integrate issues regulated by law and global competitiveness. Other levels of complexity are noticed when law required third parties involvement.*	*Ability to apply measures that involve not only ecological questions, but also questions of corporate responsibility, the promotion of ethical investments, community involvement, and improved working conditions, among others. (Boiral et al, 2008)*
	2.2	**Integration level of seemingly contradictory outlooks**	*EMS.1 Q7, Q8*	*Not applicable*	*No contradictory outlooks included. Attachment to legal solutions and outlooks, including issues stated on EIA, leading other viewpoints aside.*	*Prioritize of legal viewpoints. Contradictory outlooks solved when appear legally required.*	*Recognized as green manager by presenting the ability to propose integrative viewpoints and solutions to stakeholders. (Boiral et al, 2008)*
	2.3	**Capability of understanding and addressing expectations of stakeholders**	*EMS.1 Q7,Q8*	*Not applicable. There is not stakeholder analysis.*	*The stakeholder analysis is legally required but is not or is partially integrated in the company's goals.*	*Stakeholder analysis reveals priorities on expectations to deal with. Governmental and organizational are the most important.*	*Widely able to find the middle ground between those expectations and organizational activities (Boiral et al, 2008)*
	2.4	**Capabilities of adaptability and organizational practices change**	*EMS.1 Q9*	*No intentions on introducing changes into the process, therefore there is a low adaptability capacity to new technologies and to increase on authorities requirements.*	*Able to adapt or change practices only when averting of legal breaches requires it. No innovation or interest is actually demonstrated.*	*Adaptations on the moment of revision of the system and finding non-compliances within the established management and/or process(es) involved. There is perceived low prevention of future danger scenarios.*	*Well-developed capacity to anticipate and adapt, in order to be prepared for the emergence of new trends, constraints, and opportunities (Boiral et al, 2008)*

MATRIX OF ENVIRONMENTAL BEHAVIOURS ON ELEMENTS OF REVISION.							Page 3 of 7
Levels of performance / Environmental behaviour →				**Environmentally inadequate**	**Environmental legally accepted**	**Environmentally Active**	**Environmentally Proactive**
SECTOR	**EVAL. CODE**	**Elements of revision**	**Q/E ID.**	**D**	**C**	**B**	**A**
3. WORKERS INVOLVEMENT	**3.1**	**Awareness on environmental company's policy (EP)**	*WI.1 Q4*	*No applicable – No existence of EP.*	*Existence of EP. Awareness only on some legal obligations.*	*EP is known by the company's workers, which are involved in the EP commitment.*	*EP is not only known, but understood by the workers, who are able to detect environmental elements oriented to meet the EMS objectives of the company.*
	3.2	**Risk Awareness – Identify of HS during process and adequate handling knowledge**	*WI.1 Q1, Q2, Q3*	*Non risk perception. Workers don`t really realize they're exposed to high danger. They have no training on handle HS or emergency situations.*	*Immediate hazards and attention measures are identified (e.g., burn, explosiveness, irritation), general storage safety conditions are identified but not precisely known the reason.*	*Awareness from C, but adding knowledge of specific conditions of storage that substances require. Besides immediate attention, communication with managers is identified as an important action on emergency situations. Emergency measures are learned in training programs.*	*Most HS identified from immediate danger and long term exposure danger. General and specific storage conditions are identified, and the reason of their significance is understood. Emergency measures are applied and learned as in B, but with supplementary diffusion and visual emergency attendance signalization.*
	3.3	**Level on Safety equipment** ***(Personal protective equipment, PPE)***	*VI.1 E12*	*Absence of PPE or inadequate, and no surveillance of use.*	*It is required to identify PPE according to established regulations, but no necessary to have documented control on the supervision system.*	*PPE is identified according to established regulations. Usage is established on documented procedures. No control of usage supervision is required.*	*PPE is identified according to products' Safety Data Sheets (SDS) . Usage is established in documented procedures. Supervision is frequent and included as required control in the established EMS.*
	3.4	**Frequency of exposure**	*WI.1 Q6* *VI.1 E11*	*The level o worker's exposure frequency is not revised or limited.*	*Legal exposure limits when substance is recognized as hazard from local authorities; if not only regular labour hours.*	*Exposure limits are established by SDS recommendations. Exposure limits and labour hours are established as in level C. Planned rotation of shifts and/or area of labour reduce levels of exposure.*	*No exposure due to technology adaptations. Existence of supporting analysis that backs up absence of risk of exposure.*
	3.5	**Risk Communication level**	*WI.1 Q3, Q7*	*There is a deficit on organizational level; workers don't know who is responsible or the appropriate person to take decisions in order to solve environmental accidents.*	*Workers identify risk signalization and hazard information about the chemical products handled.*	*Workers identify from training programs risk exposition and chemicals hazards. Workers are able to identify immediate responsible to come with in emergency situations. .*	*Workers attend regularly to risk communication training programs as in level B; they recognize a clear communication chain that allows identifying responsible in these and other involved areas. Control and diffusion of risk planning programs.*
	3.6	**Inclusion of workers comments, ideas or experiences to improve environmental performance.**	*WI.1 Q8*	***Mark as C*** *Workers are not taken into account in the decision process; they are limited to obey established rules. Regularly, no legal breach is found; however, it blocks improvements opportunities and detection of possible further legal breaches. Then, it is classified as inadequate for the EMS functioning.*		*It is stated management openness to the workers comments in order to contribute to the continuous improvement process.*	*Management have openness to workers comments as in level B. Additionally, exist incentive programs to motivate workers interest on the EMS improvement.*
	3.7	**Training emergency programs**	*WI.1 Q9*	*These programs are not included in the workers training program.*	*Workers attend training required before start working for the first time.*	*Workers attend training courses required and keep registry of it. Repetition enforces learning.*	*<u>Workers attend training as in level B.</u> Additional practice and updating training is programmed, planned and provided. There is revision of learning progress.*

MATRIX OF ENVIRONMENTAL BEHAVIOURS ON ELEMENTS OF REVISION.							Page 4 of 7
		Levels of performance / Environmental behaviour →		Environmentally inadequate	Environmental legally accepted	Environmentally Active	Environmentally Proactive
SECTOR	**EVAL. CODE**	**Elements of revision**	**Q/E ID.**	**D**	**C**	**B**	**A**
4. OCCUPATIONAL HEALTH AND SAFETY IN THE STORAGE AND USE OF HS SUBSTANCES	**4.1**	**Planning and registry control on the storage of HS**	*VI.1 E4, E5*	*Breaches found according to local established regulations in the matter.*	*Identification of elements from risk communication plan (see element 3.5) in the **storage site**. Registry on quantities on remaining and required HS. SDS of all chemical substances involved.* ***Mark as B only if documents are included / indexed in the established EMS and present improvements in the past 3 years.***		*<u>Control as in level B. Plus:</u> Inclusion of documents in established EMS. Revision and updated of procedures max. 3 years. Precaution measures in case of increase of storage quantities.*
	4.2	**Containers of input hazardous materials status**	*VI.1 E1, E2, E3*		*Label and package as indicated in SDS information. Containers grouped and distant; segregations barriers.* ***Mark as B only if these indications are included in the established EMS and present improvements in the past 3 years.***		*<u>Control as in level B. Plus:</u> Identification, labelling and packing are actualized according to GHS.*
	4.3	**Safety site measures in the storage of HS**	*VI.1 E6, E7, E8, E9, E27*		*Adequate according type of HS; general measures established following legal requirements on **storage site** for chemical substances (e.g., signalization, emergency infrastructure).* ***Mark as B only if these indications are included in the established EMS and present improvements in the past 3 years.***		***Storage site** safety measures take into account particular requirements in SDS of HS. Efficiency supported by proved no accidents in a minimum 6 months period.*
	4.4	**Planning and registry control on the use of HS**	*VI.1 E13*		*Identification of elements from risk communication plan (see sector 3.5) in the **process(es) where HS are used**. Registry on machinery and equipment operators. Documented procedures for use of HS and machinery maintenance.* ***Mark as B only if documents are included / indexed in the established EMS and present improvements in the past 3 years.***		*<u>Control as in level B. Plus:</u> Revision and update of procedures max. 3 years. Diffusion and incentive programs on proper use of HS. Precaution measures in case of production increase. Other voluntary emergency preparedness measures.*
	4.5	**Worker's protection measures in the use of HS**	*VI.1 E12*		*Verified used of PPE in the plant on the process(es) that involve HS (according to level C, element 3.3). Signalization indicating use of this PPE is also identified.* ***Mark as B only if these indications are included in the established EMS and present improvements in the past 3 years.***		*Verified used of PPE in the plant on the process(es) that involve HS (according to level A, element 3.3). Signalization and supervision on the use of PPE is also identified.*
	4.6	**Safety site measures in the use of HS**	*VI.1 E13, E28, E29*		*Adequate according type of HS; general measures established following legal requirements on **workplaces that use HS** (e.g., signalization, emergency infrastructure).* ***Mark as B only if these indications are included in the established EMS and present improvements in the past 3 years.***		*Safety measures for **workplaces that use HS** take into account particular requirements in SDS of HS. Efficiency supported by proved no accidents in a minimum 6 months period.*
5. HS AS INPUT MATERIALS	**5.1**	**Responsible care from suppliers**	*PM.1 Q1*	*Not revised*	*Authorized permission for chemical products trading.*	*Compliance and certification with management standards (e.g., ISO 14001, ISO9001)*	*Responsible Care® or similar certification*
	5.2	**Awareness level on the HS quantities used in the company and about the risk they represent.**	*PM.1 Q2*	*Unknown or risk perceived by empirical knowledge.*	*Quantities of HS handled do not represent risk according to **local authorities'** parameters.*	*Quantities of HS handled do not represent risk according to **international parameters** or SDS information.*	*Registry on quantities used and supporting work environment analysis indicate no risk either for natural environment in the surroundings or occupational health.*
	5.3	**Actual number of HS substances that the company use, including level of hazard**	*HSA.2*	*Almost all (~80%) of all chemical products used are considered hazard; or cannot be determined due to SDS omission.*	*Many chemical products used are considered hazard (~50-80%); The company counts with all substances SDS from supplier and permission of use (in case of required).*	*Not many chemical products used are considered hazard (less than >50%); SDS and permissions as in level C.*	*No hazardous substances are used in the process(es) in the company.*

MATRIX OF ENVIRONMENTAL BEHAVIOURS ON ELEMENTS OF REVISION.							Page 5 of 7
Levels of performance / Environmental behaviour →				Environmentally inadequate	Environmental legally accepted	Environmentally Active	Environmentally Proactive
SECTOR	**EVAL. CODE**	**Elements of revision**	**Q/E ID.**	**D**	**C**	**B**	**A**
5. HS AS INPUT MATERIALS	**5.4**	**Research level on replacement of HS in the process**	*EMS.1 Q4* *PM.1 Q3*	*No interest perceived on environmental improvements.*	*No research, but other factors point this as best. No HS replaced in more than 5 years.*	*Interest on replacement, research carried out and documented. No HS replaced in more than 5 years.*	*Research has been done and some substances have been replaced since 5 or less years ago.*
	5.5	**Level of recovering and recycling materials.**	*VI.1 E10*	*Substances are not recovered or recycled in the plant's process(es).*	*Some substances are recovered and reused in the same process(es) or in others in the same plant.* ***Mark as B only if documents are included / indexed in the established EMS and present improvements in the past 3 years.***		*All substances are recovered and reused. There is no production of hazardous waste in the industrial plant.*
	5.6	**Research and introduction of "clean technologies" in the processes**	*EMS.1 Q4* *PM.1 Q4*	*No interest perceived on environmental improvements.*	*No research, but other factors point actual technology as the best. Actual technology is classified as end-of-pipe to reduce environmental impact.*	*Interest on replacement, research carried out and documented. Actually counts with in-line technology to reduce waste generation and materials recovery.*	*Research has been done and the plant actually counts with in-line technology to save energy consumption, avoid waste generation, recycle materials or reduce CO_2 emissions.*
6. WASTE TREATMENT OVERVIEW	**6.1**	**Water discharge limits compliance**	*PM.1 Q5*	*Unknown – no revision*	*Treated wastewater pollutants concentrations are below limits established by local authorities.*	*Treated wastewater pollutants concentrations are below recommendations of World Health Organization (WHO) water pollutants limits*	*No wastewater, nor treated wastewater is produced by the plant's process(es)*
	6.2	**Extension of HS-waste treated in the company.**	*VI.1 E15*	*There is no treatment; or HS are not identified to be included in the treatment.*	*Many of the identified HS are included in the plant's treatment.*	*All identified HS are included in the plant's treatment.*	*The plant does not generate hazardous waste.*
	6.3	**Treatment Environmental impact**	*VI.1 E16*	*There is no treatment.*	*Treatment authorized by local authorities. Since only physical separation is done, environmental impact is considerable due to no hazard change in final generated waste.*	*Physical, chemical and/or biochemical treatments that reduce waste hazard and is authorized by local authorities.*	*Treatment applied is classified as clean technology. Do not generate significant quantities of pollutants or hazardous waste; nor use hazardous substances in the process.*
	6.4	**Research and Introduction of "clean technologies" on HS Treatment.**	*EMS.1 Q4* *PM.1 Q4*	*No interest perceived on environmental improvements.*	*No research, but pointed technology as the best. Actual technology is classified as end-of-pipe to reduce environmental impact.*	*Research carried out and documented. The plant counts with in-line technology to reduce waste generation and materials recovery.*	*Research has been done and the plant at present time counts with in-line technology to save energy consumption, avoid waste generation, recycle materials or reduce CO_2 emissions.*
	6.5	**Technology performance on discharge quality values**	*PM.1 Q4, Q5* *VI.1 E16*	*No treatment or inefficient to meet authorities' limits of pollutants in treated wastewater.*	*Good enough and no additional procedures are required to meet local authorities' limits of pollutants in treated wastewater.*	*As in level C, plus pollutants concentrations in treated wastewater are below WHO recommendations.*	*Technology applied is classified as clean technology, and has been designed to save energy consumption, avoid waste generation, recycle materials or reduce greenhouse gases emissions.*

MATRIX OF ENVIRONMENTAL BEHAVIOURS ON ELEMENTS OF REVISION.							Page 6 of 7
Levels of performance / Environmental behaviour →				**Environmentally inadequate**	**Environmental legally accepted**	**Environmentally Active**	**Environmentally Proactive**
SECTOR	**EVAL. CODE**	**Elements of revision**	**Q/E ID.**	**D**	**C**	**B**	**A**
7. HS AS FINAL COMPANY'S GENERATED WASTE	**7.1**	**Final hazard level of obtained waste after treatment.**	*PM.1 Q6* *VI.1 E14*	*Unknown or not identified.*	*Waste identified as hazard according to local authorities.* *This empirically known since there is no analysis of treated waste.*	*Waste identified as hazard according to local authorities or international parameters.* *Supported analysis by authorized laboratories demonstrate hazard of generated waste.*	*The plant does not generate hazardous waste.*
	7.2	**Waste generation vs. production ratio over time.**	*PM.1 Q8*	*Rate has Increased from one year to now.*	*Rate has been maintained, probably there has been not change of HS or technology.*	*Rate has reduced from one year ago.*	*There has not been generation of hazardous waste from one year until now.*
	7.3	**Emissions generation vs. production ratio over time.**	*PM.1 Q9*				*Atmospheric emissions are reduced to zero from one year until now.*
	7.4	**Hazard level of generated waste over time**	*PM.1 Q7*	*Unknown / Has not changed*	*Yes, just below national guidelines*	*Yes, just below international guidelines (specify guidelines)*	*Proved non-hazard*
8. HAZARDOUS WASTE (HW) TEMPORAL STORAGE	*****IN CASE THE COMPANY HAS NO HAZARDOUS WASTE GENERATION, THIS SECTOR SHOULD BE ELIMINATED.***						
	8.1	**Planning and registry control on the storage of HW**	*VI.1 E24, E25*	*Breaches found according to local established regulations in the matter.*	*Identification of elements from Safety Management and Hygiene Program (see element 3.5) in the **HW storage site**. Registry on quantities sent to treatment or confinement.* ***Mark as B only if documents are included / indexed in the established EMS and present improvements in the past 3 years.***		*Proved as sufficient; Prevention of future scenarios of increase quantities.*
	8.2	**HW containers status**	*VI.1 E17, E18, E19*		*Label and package as indicated in applicable regulations including hazard classification and production area of origin.* *Containers grouped and distant; segregations barriers.* ***Mark as B only if these indications are included in the established EMS and present improvements in the past 3 years.***		*<u>Conditions as in B, plus:</u> Label according to international guidelines (UN-HAZMAT) and package from the same material (or the same) of the original substance.*
	8.3	**Safety site measures in the storage of HW**	*VI.1 E20, E21, E22, E23, E30*		*Adequate according type of HW; not mixed; containers' general measures established following legal requirements on **HW storage site** (e.g., signalization, emergency infrastructure).* ***Mark as B only if documents are included / indexed in the established EMS and present improvements in the past 3 years.***		*Proved as sufficient; Prevention of future scenarios of increase quantities.*
	8.4	**Adequate and safe HW temporal storage time and maintenance**	*VI.1 E26* *PM.1 Q10*	*Waste sent for treatment is uncontrolled.* *Particular containers are reused and their conditions are not revised,*	*According to local legal requirements (regularly <6months).* *Particular containers are replaced after sent; large industrial are not replace nor maintained just emptied*	*Storage time and particular containers management as in C, plus industrial containers are revised for physical resistance.*	*Storage time is variable, since waste is sent before represents significant risk.* *Particular containers are replaced after last ones are sent to treatment; industrial ones are cleaned/maintained to prevent risk (replace if necessary).*

MATRIX OF ENVIRONMENTAL BEHAVIOURS ON ELEMENTS OF REVISION.							Page 7 of 7
		Levels of performance / Environmental behaviour →		Environmentally inadequate	Environmental legally accepted	Environmentally Active	Environmentally Proactive
SECTOR	**EVAL. CODE**	**Elements of revision**	**Q/E ID.**	**D**	**C**	**B**	**A**
9. HS FINAL DESTINY – KNOWLEDGE AND VERIFICATION LEVEL	**9.1**	**Following stages of the generated waste.**	*PM.1 Q12*	*Unknown*	*Known / Records of consignment notes of HW reception. Copies of legal permissions as waste collector service supplier.* ***Mark as B only if documents are included / indexed in the established EMS and present improvements in the past 3 years.***		*Known / Possession of supporting documents as in B.* *Following stages do not represent negative environmental impact.*
	9.2	**Hazardous waste safe transportation.**	*PM.1 Q11*	*Not conditions verification*	*Records and revision of documents and legal authorizations from the service supplier company.* ***Mark as B only if documents are included / indexed in the established EMS and present improvements in the past 3 years.***		*Records and revision of documents and legal authorizations as in B, plus: vehicle's conditions revision at the moment with own plant's personnel.*
	9.3	**Waste treatment previous deposition**	*PM.1 Q12*	*Unknown / Unsafe/ Inappropriate*	*Waste treatment is permitted by local authorities. However it represents possible negative environmental impact (e.g., incineration)*	*Waste treatment is permitted by local authorities. Deactivation and deposition by a service supplier company with a management certification.*	*Waste treated and recycled or reused by other companies without representing environmental deterioration.*
	9.4	**Waste final destination location.**	*PM.1 Q13*	*Unknown / Unsafe/ Inappropriate*	*Known and supporting documents of location, but no additional information of the site's conditions.*	*Knowledge of site as in C, plus information of site's conditions and supporting documents of safety and responsible management.*	*Waste is not confined, but recycled or reused.*