ISO 14001 implementation: translation process and organizational change

Thomas Reverdy

THOMAS REVERDY[1]

Translation Process and Organizational Change: ISO 14001 Implementation

Abstract: The purpose of this study is to find out how local translations of a generic management system reduce organizational uncertainties, produce technical and organizational knowledge, and introduce cooperative relations, cross-functional learning and problem identification and solving. The study uses the organizational dynamics associated with the implementation of an environmental management system (EMS), according to ISO 14001, in a chemical plant to answer those questions. Based on an ethnographic study the article unravels the way in which ISO 14001 requirements are interpreted by environmental managers and production teams and, then, translated to fit their organizational context, i.e. the specific industrial managerial cultures and organizational issues. The article conclude that the production and circulation of artifacts embodying extensive knowledge about the production activity and its impacts on the environment counterbalances dependency of company's environment departments on other departments and increases environment department ability to mobilize teams around the environmental stakes.

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[1] Thomas Reverdy, Organizational Studies and Industrial Sociology, PACTE, Université Pierre Mendès France, 38040 Grenoble Cedex 9, Thomas.Reverdy@upmf-grenoble.fr, Tel: 04 76 82 55 28

An increasing number of organizations have adopted the ISO 14001 Environmental Management System (EMS) standard and obtained certification. The emergence of such voluntary actions corresponds to a need to rationalize internal management, restore the general public's faith in industry and create differentiation in order to increase competitiveness (Delmas 2002). The ISO 14001 standard transposes the rules of quality management, as formalized through the ISO 9000 standards, to the realm of the environment. This managerial standard invites companies to organize and formalize their environmental management methods with the objective of obtaining certification, and emphasizes the following: management commitment, planned improvements, formalized processes, organization of corrective and preventive actions and staff training. Implementing ISO 14001 is one approach to integrating environmental issues in daily work routines.

Much of the research on ISO 14001 is based on interviews with company managers and focuses on why they decide to introduce certification, the conditions for successful implementation, and the effects of this implementation (Delmas 2002, Jiang and Bansal 2003, Kirkland and Thompson 1999). In this research, the ISO 14001 environmental management system is, however, treated as if it was taken for granted, and not as something subject to multiple interpretations and appropriation. Emphasis is placed more on the function of what is being diffused than on how this is happening, giving little attention to the role of actors and action in the implementation process. There is a lack of any in-depth reports on the implementation of the standard in industrial organizations.

Some empirical studies report on the managerial difficulties encountered when implementing pollution reduction projects (Dieleman and Dee Hoo 1993; Cebon 1993; Remmen 1995; Boiral 2002). These works underline the complexity of these projects and the difficulties mobilizing the actors concerned. There are some interesting articles on how management tools like environmental accounting (Füssel and Georg 2000) or the participative approach (Rothenberg 2003; Boiral 2002) help to mobilize organization's members with respect to environmental issues. However, these articles do not offer any systematic analysis of the strategies adopted by those involved and the relations between them. Indeed, the social and organizational embeddedness of the company's employees is often overlooked.

This article fills this gap by analyzing what the implementation of ISO 14001 on a chemical site entailed for the people working with the system. The article demonstrates the way in which ISO 14001 requirements are interpreted by employees in their daily concerns and work routine**.** It explains how they apply quality tools and routines to environmental issues, and describes how theses tools help actors to jointly produce new technical and organizational knowledge and a common vision of the relation between industrial activities and environmental issues. Finally, it shows how this shared knowledge scales down the dependency of environment departments on other departments and helps to set up new cooperative relations between the environment department and other departments.

The methodology and the theoretical framework adopted in this research are presented first, followed by the observations and their proposed interpretation. This calls for an overview of the environmental management practices I observed before ISO 14001 was put into place. Emphasis is being put on the organizational dimension, in particular, on the high dependency of the Environment Departments on other departments as well as uncertainty about their willingness to cooperate. In keeping with the narrative tradition generally adopted in organizational studies (Czarniawska-Joerges 1998), this article presents a series of "stories" that recount the writing up of procedures and describe the management instruments and technical devices implemented during the project: planning procedure, accidental pollution management procedure, etc.

Theoretical framework

The notions of division of work and dependency relations play an important role in my analysis of the consequences of ISO 14001 implementation. It is important to bear in mind the kind of knowledge required to integrate environmental considerations in industrial processes and activities. Such knowledge depends on the type of technical strategy adopted. Two distinctions can be made in order to describe the technical strategy and its consequences in terms of mobilized knowledge.

The first distinction is one commonly found in literature on management. It concerns "additive technologies" and "integrated technologies" (Patris, Warrant and Valenduc 2001). Additive technologies add to existing technologies without modifying the way they operate. Integrated technologies seek to optimize the production process from an environmental perspective, i.e. by reducing pollution and resource use. The second distinction is less common: it is the difference between investment and continuous improvement. It is often possible to enhance environmental performance without making substantial investments in technology but by adjusting and improving existing work practices and equipment. . Industrial processes are sensitive to the ways in which they are managed, but improvements can be made by re-organizing these routines. There are also many production-related activities that can have substantial positive environmental impacts and which can be organized without having to make considerable investments in changing the production processes, e.g., separation of wastes, management of accidental leaks, and maintenance.

Different technical solutions do not have the same consequences in terms of organization. Continuous improvement and process-integrated prevention are more demanding than additive solutions in terms of shared knowledge and coordination within the company. Depending on the technical solution adopted, whether based on additive technologies or integrated technologies, investment or continuous improvement, different corporate functions are concerned. In the case of additive technologies, the environment manager works with external experts in environmental technology. Wherever possible, their work is often performed separately from the rest of the organization. In the case of integrated technologies, the circle of people involved widens to include technical experts specializing in the production process itself: R&D departments, production engineering staff or external experts (suppliers). The project no longer falls within the scope of responsibility of the environment manager alone as the environmental concerns are woven into the very dynamics of industrial innovation. Process and production engineers have their say in validating or not the new technologies. Many accounts show that this validation process is not easy. The study carried out by Le Blansch (1995) on the strategies adopted by printers to integrate cleaner technologies emphasizes how difficult this is. Introducing cleaner technologies is therefore not as easy as one might think. Trying, for instance, to improve the environmental performance of equipment (continuous improvement) requires production managers and teams to selectively sort waste in order to control variations in the polluting agent upstream of a water treatment facilities so as to avoid accidental pollution (Boiral 1998 and 2002, Rothenberg 2003). This entails working with other departments, each of which is likely to be fueled by different types of rationality (Friedberg 1993): each employee has his or her own reason to cooperate or not.

My main hypothesis is that the generic requirements of ISO 14001 are translated into specific routines affecting the daily production activities as the system is implemented. In order to discuss this hypothesis, I need to clarify my definition of the translation process and explain how ISO 14001 implementation (especially formalization activities) supports this process.

Improving environmental performance requires a translation of environmental objectives into the production system. This translation is not only a technical but also a managerial activity, a process which as defined by Callon (1986), underlines the dynamics of "problematisation", “interessement” and “enrolment” of actors. "Problematisation" (Callon 1986) implies that the actor (in this case the environment manager) attempts to introduce his or her objectives (environmental objectives) as an "obligatory passage point" for the other actors. This is done through a process of "interessement" that modifies the context in which employees act (through new requirements and new resources, including technical resources) and the definition they have of their own “interests”. It means adapting the environmental objectives to the specific context of actors. “Enrolment” appears when the “interessement” is achieved and actors play the role expected of them. Which kind of technical and organizational resources are produced by ISO 14001 implementation and how do these resources modify relationships and activities? ISO 14001 requires improving and formalizing the activities related to environmental issues, defining the responsibilities of each function, controlling environmental performance and work practices, and continuously improving overall performance. These requirements can be interpreted as a rationalization or a bureaucratization of environmental management. But this interpretation is incomplete, because it overlooks the performative aspects of ISO 14001 implementation as an organizational project. Through the course of the implementation process different actors interact to produce new technical and organizational resources – formal documents, management tools and technical devices – that, in turn, ‘perform’ by directing attention, allocating resources, changing work routines, etc.

The ways in which ISO 14001 requirements are interpreted in an organizational context depends upon the specific industrial management culture. By industrial management culture I mean formalization practices, compliance attitude, problem solving practices (problem analysis and decision process) and the relation between production and functional teams. In many industrial units there has been a general move from Taylorism to quality management; an industrial management culture based on a socio-technical approach to process improvement (e.g. involving employee participation). Although the organizational resources produced through ISO 14001 implementation process are noted for contributing to the control of employee behavior, it also allows for knowledge production and circulation.

The production of these new organizational resources (knowledge, formal roles, control devices) can have a significant effect on dependencies, power relations between various departments/functions within a company, e.g., the environmental function and production function. As actors reorganize their relations and their work routines they may also acquire new organizational resources. In order to show how these processes takes place it is necessary to analyze how formal rules are interpreted *in situ* and attending to the detail on how participants produce, debate, use process knowledge, and how a plant manager, environmental department, and production department negotiate the definition of responsibilities .

Hence, ISO 14001 implementation does not necessarily mean bureaucratization, but it can also be an opportunity to develop new organizational resources that support coordination in order to develop integrated solutions and continuous improvement. Several studies confirm the importance of coordination: Rothenberg (2003) and Boiral (2002), for example, show that more cross-functional and participative management practices, when these work properly, produce highly advantageous results in terms of reducing pollution. By analogy, the collective writing of procedures and work instructions during the implementation of ISO 14001 can provide new links between teams, which up until then have 'lived their separate lives'. The formalization activity can have a similar role to that of the cross-functional teamwork outlined in the research of Hatchuel and Weil (1995). Multiple learning dynamics are introduced by such cross-functional devices as reported on by Nonaka (1994). With this kind of cross-functional team, knowledge that was hitherto tacit, controlled by the production teams, and seldom available elsewhere in the company, becomes more readily accessible (Boiral 2002; Rothenberg 2003). It also encourages the emergence of knowledge that is more formalized, and which is generated jointly by the production, engineering and environment functions.

Methods

This article has an ethnographic edge. It is based on my own participative observation of the implementation of ISO 14001. This took place in a large-sized French chemical plant, employing 2000 persons, and lasted about 4 months during 1996. The chemical plant was an old industrial site using highly heterogeneous technologies. It was faced with increasingly strict regulations on pollution. It had made considerable investments to reduce its continuous pollution but still had to deal with considerable accidental pollution. The site had set itself the objective of reducing this accidental pollution through better preventative measures and increased reactivity to incidents.

Working as a trainee engineer in the environmental team I was able to see what was at stake from a technical point of view and I participated in writing the procedures and in designing management tools and technical devices. I took part in many informal conversations (with up to 30 persons from different departments). This helped me understand the attitudes, reasoning and practices of the various people involved. As a trainee, I enjoyed considerable freedom in the way I acted and moved around the company. I was not directly attached to the environmental department or in charge of setting up ISO 14001 in the way that a consultant is. Of course, I cannot say that my presence did not have an influence on what I observed and I sometimes found myself acting as a facilitator or mediator. Having been trained in ethnographic survey techniques (Vinck 2003), I kept a logbook of my observations, discussions during meetings, technical sketches and drafts (over 300 pages of notes, with about as many pages of photocopied internal documents). One year later I returned to the chemical site to perform several interviews with the members of the environmental department, here again, in an informal manner.

Following this experience in the field, I organized my observations theme by theme: waste reduction, risk assessment, planning, drafting of work instructions, prevention of accidental pollution, etc. I also made a note of the behaviour I observed in each function regarding environmental concerns, the justifications for such behaviour and the way people belonging to other functions judged it. I reconstructed the background for each management instrument implemented, i.e., risk identification system, accidental pollution research procedure, improvement planning, process management procedure, and waste reduction working group methods in order to understand the issues that the employees associated with each one. I also gathered the accounts of a number of projects or incidents that mobilized different departments.

Inspired by the sociology of translation (Callon, 1986) these accounts were then structures so that: they identified the people involved, their expectations, the conventions, the tools and practices mobilized, the different stages in the development of these instruments and systems, the difficulties encountered, the conflicts and negotiations, and actors' use of the various instruments. During the few months in which I was present in the company, I was able to observe changes induced by these instruments, modifications of behaviour and emerging technical or organisational solutions. For each of the topics dealt with by the working groups, I tried to draw a link between the arguments exchanged, the description of the instruments set up and my observations of daily practices.

To draw the conclusions from each specific account and report on the complex relations between the implementation of the standard and the organizational dynamics observed I adopted a method based on inductive reasoning. The aim here was to interpret the collective activity involved in drafting and implementing procedures or management tools and hence produce a more global vision of the organization and its transformation. This global vision emphasizes the division of work and knowledge and the cooperative relationship between the production teams (as well as the break-up of tasks and knowledge within these teams) and the environment department. Specific focus is therefore placed on the relations of dependency (Pfeffer 1981; Friedberg 1993) between the environment department and the production teams. I wanted to understand to what extent environment managers depend on the competence of production teams and their active participation, and how the implementation of ISO 14001 may change this.

I attempted to reduce personal bias in interpreting organizational change through different means. As a trainee, I had the opportunity to observe and interact easily with people from different levels of the organization and different departments, without being labeled as member of a specific team. As a result, my interpretations are based on different sources from within the company, thus, avoiding the managerialist slant that characterizes much environmental management research. During the course of my stay in the company I came to play a facilitating role – bridging the divide between the environmental department and other departments – that also introduces a bias. This was not something that I had planned. It was a role which was constructed by the organizational situation and which revealed the lack of coordination between these departments. However, I regularly presented my research work to a research committee of confirmed sociologists in order to discuss my interpretations and evaluate personal and situational bias.

Findings

Before ISO 14001: Dependence of the Environment Department on other departments

This section looks in particular at the tension between the environment department and other departments observed before ISO 14001 was implemented. Such tension is seen to be the result of relations based on dependency (Pfeffer 1981; Friedberg 1993). The environment manager relies on the competence of production teams and their active participation in order to assess situations, look for solutions and validate these.

The environment manager in the chemical plant gradually developed the following strategy: Anticipation of regulatory requirements (including even stricter internal requirements), management of pollution reduction (requiring operational management to find ways to reduce pollution from the industrial process), and optimization (involving a sharing of effort between different workshops, aiming at those where the cost was lowest). Indeed, without gaining a precise understanding of the risks and causal relations between equipment control practices or operational problems and downstream pollution the environment department would not have been able to draw up a list of priority actions and define credible objectives.

In my role as trainee engineer, I observed that the intention to optimise the process had to go hand in hand with an in-depth knowledge of that process. This knowledge of the process is distributed among different people, is little formalized, and associated with much uncertainty. The ways in which production processes actually function is very different from any theoretical description, e.g., as defined when the process was designed. They are likely to be subject to deteriorations and improvements over time, and in the mean time the production teams have learned to manage and work with heterogeneous equipment. As a consequence, knowledge of process operation is increased and shared during optimisation campaigns to obtain, for example, a higher level of quality. The processes by which knowledge sharing takes place in environmental issues has not been studied in a systematic and in-depth fashion.

Generally speaking, when environment managers embark on their projects they find that they depend greatly on operational managers, on their knowledge but also on their willingness to perform internal investigations. Given how difficult it is to assess and check the commitment of operational management, it is impossible to reduce this dependency. As it is not always within the interest of production engineers and managers to cooperate, it is not easy to obtain their buy-in to the environmental project. It must be remembered that production equipment control is the result of a set of compromises between various contradictory objectives: limiting risks, optimising product quality, ensuring equipment durability, and staff safety. Introducing yet another parameter, i.e. environmental considerations, can call into question the overall balance of the system and is likely to involve long, complex and costly experimentation. In the chemical plant, the production engineers found themselves confronting foremen and operators on a number of issues, e.g., emissions and pollution unknown to workshop management, lack of investment in problem solving, unknown consequences. Moreover, participative culture was fairly weak in the plant, and the workshop managers encountered real problems trying to mobilize production operators.

Mobilization strategies

The environmental manager's strategy was to be more proactive and seek to anticipate regulatory requirements, whereas the engineers and unit managers merely considered regulations as rules to be complied with. The environmental manager's mobilization tactics used were somewhat aggressive and included defending a number of specific positions within the executive committee. It was a demanding strategy in terms of energy, and it was not very effective because the unit managers' opinions did not change and they did contribute with the necessary insights/knowledge to improve environmental performance. The environment manager did not have access to the knowledge of the process needed to direct projects and/or identify the best opportunities for reducing pollution.

The main challenge in developing integrated solutions is that this requires production teams to be strongly committed, and yet they only have limited visibility and, hence, interest, in projects of this kind. Operational managers often feel that senior management ignores the efforts needed to develop integrated and environment-friendly practices. Consequently, there is a lot of uncertainty surrounding the environmental issues, which discourages teams from getting involved. At the same time, production teams may feel that their commitment helps to keep equipment in working order, hence making costly modernization investments unnecessary. In other instances, there is not enough engineering expertise or enough time available to analyze operational problems and define modifications.

In the chemical plant, for example, the environment manager was often confronted with abnormally high concentrations of pollutants tracked down in the factory sewage system. Locating the source of these pollutants, a job that was assigned to the production supervisors, regularly failed. Consequently, senior management criticized everybody. Their judgement of the situation, whether this was expressed or simply perceived, only increased the barriers for cooperation.

Hence, when attempting to implement a project, an environment manager often comes up against barriers formed by the lack of access to certain knowledge or be confronted with the production staff's unwillingness to be mobilized. These barriers, or areas of "opaqueness", are necessary for employees to keep hold of their autonomy (Friedberg 1993), and are subject to the informal rules that play a significant role in teams of professional workers. Workshop managers sometimes adopt this type of strategy when they feel that too much transparency with respect to the activity in their workshop would put them in too fragile a position. They are also limited by their own lack of knowledge about the activity of their teams. A lack of understanding about production activities makes it all the more difficult to translate environmental requirements, ensure control and set up incentives.

ISO 14001 Implementation: Translating the quality organization

The concept of the environmental management system (EMS) uses many of the rules emanating from quality assurance standards, and many companies implement environmental management systems by extending practices and tools from a pre-established quality management system to also include environmental issues (Reverdy 2003). The environmental management system is tied to the ways in which quality management is organized, and draws upon the language, the conventions, the established routines, and the coordination instruments put in place to ensure quality.

For the chemical company, Quality practices were already deeply engrained in the company's culture, to the point that they permeated all management activities. The quality documents, and in particular quality-related forms, were seen as genuine tools for facilitating coordination between departments. Whenever a given activity involved several departments, a documentary tool was formally drawn up to manage the activity better. Implementing ISO 14001 entailed using quality tools in an environmental context, e.g., : Accidental pollution could be prevented by drawing upon the company's experience in metrology , as well as in process representation and tracing failing equipment, structured information distribution, incident causal analysis, and preventive action programming. Waste management benefits accrued from previous work in product traceability.

In what follows particular attention will be given to the 'instrumentation' that ISO 14001 entails, e.g., risk assessment and improvement planning instrument, process control rules or maintenance management instructions and accidental pollution research and location procedures. All these instruments emanate from quality management but their use provides solutions to organizational issues.

The production and circulation of technical knowledge

Management systems consist of a host of generic tools and procedures. The ways n which these tools work is a matter of how they are interpreted and how they are subsequently put into place. However, the extent to which these formal instruments organize production and allow knowledge about activities and process operation to be passed on; the limits of these instruments; the development of alternative types of knowledge exchange that do not require formalization; and the link between production of knowledge and production of organizational rules and roles are all issues that have to be studied empirically. The issue pursed in the following is how new shared knowledge makes it possible to develop shared rules and objectives. This is cast as a matter of translation (Callon 1986) and depends on the capacity of actors to define and enrol entities into the task.

Calculating the environmental risk

Introducing ISO 14001 requires identifying the company's main environmental impacts (or performing an environmental analysis). The one's responsible for this were the production teams who sought to represent the company – its material flows and equipment – "from an environmental point of view." They "mapped" emissions and flows of pollutants, analysed the various stages in the process with the aim of defining cause and effect relations between the process, the method used to control it, the various operations involved and the type of upstream emissions. Inspired by existing quality improvement methods, they studied various risks associated with production, e.g., exchanger leaks, burst piping, shifts in chemical reactions, and malfunctioning distillation columns. The approach taken is exemplified in the following conversation:

> Environment manager: "*we need to calculate the various emissions from your workshop, to track down the most important ones.*"
> Production engineer: *"but that's like opening a Russian doll, when do we stop?*
> *Production engineer: the lime milk treatment tower is forever malfunctioning, what can we do about that?"*
> Environment manager: *"if we know that it's not working properly, we need to focus on upstream equipment. We need to be able to locate the problem. That means drawing a mimic diagram and giving the figures."*
> Production engineer: *"The tower's not working in proper conditions because of pollutants from the upstream equipment. The tower can't treat them all."*

They followed a method that was well known – the production teams located equipment presenting a risk of failure, analyzed the chain-effects of such failures (with the help of the engineering department), and performed a probability assessment. The environment team commented and confirmed the production team's calculations, estimated how serious the effects were and put forward a hierarchical risk evaluation. The following table describes how each function contributed to the risk analysis tool, as well as the knowledge they each added to the calculation.

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Table 1. Risk calculation: Knowledge and actors mobilized

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The plant's production processes are converted into a number of different inscriptions that could travel back and forth between the environmental managers and the production managers to help organize their understandings of the problems at hand. The risk analysis tool developed coordination between production staff and the environment team. It produced a shared vision of environmental risks. It also had a mobilizing role. Production staff helped to analyze the risks and define priorities. This meant that the definition of the environmental strategy was transparent from the point of view of the production managers. The tool therefore helped to stabilize the relationship between the two departments.

However, coordination cannot be properly set up using these tools alone: the above-described tool provides few indications as to how to reduce risks (for example with respect to improvement opportunities). The environment manager of the chemical plant realized that although such tools were useful, he still had to visit production staff regularly in order to know more about improvement opportunities. Indeed, the very existence and limits of these tools made frequent discussions necessary. The formal tools designed to coordinate, produce and distribute knowledge were in fact complemented by these informal interactions.

Integrating the environment in work instructions

During the period spent in the chemical plant, I was able to witness the activities of the working group in charge of managing accidental pollution. Their work began by first trying to get a better knowledge of the sewerage system. This required updating plans, which was no small matter. The group also worked with supervisors and a number of operators in order to improve methods to seek out information from other operators, to analyse pollutants in the sewers and to interpret the data produced by the measuring instruments. The previously used, non-formalized practices were compared and contrasted and then completed with more precise knowledge about industrial processes and effluent flows in the sewerage system. The supervisors then finalized a document listing the various types of information research and analyses that had to be done depending on the combination of pollutants discovered in the sewers. These documents worked to accelerate the search for the source of pollution and were therefore considered as useful by everybody in the company. The following exchange illustrates the complexity of this situation:

> Production Engineer: *"When column X is correctly controlled, the quantity of pollutants is very low, most of the molecules in question are very unstable: 100 meters farther down, you no longer have the same products, and they do not generally appear in analyses."*
> Environment Manager: *"How do you keep a check on your column?"*
> Production Engineer: *"Using the temperature, and a flow meter, installed inside."*
> Environment Manager: *" There is no feedback to the control room?"*
> Production Engineer: *" Nothing, the guy has to go across to have a look."*
> Environment Manager: *" So how do you know if it's not working properly?"*
> Production Engineer: *"The online chromatograph doesn't pick up on the product. I have to wait for the lab analysis results the next day. When it's not working properly, all the contents flow through the base of the column and it wasn't designed to treat that sort of thing. It has a siphon that is not at all under control. I'm waiting for my supervisors to determine the right indicators to control it. In the meantime, the control room gets a flow rate and temperature feedback. The column works OK when it's producing foam, but even then.... As it's made of glass, it's checked visually. You've got to make sure that the foam doesn't drop down or it would all go to the base of the column."*
> Environment Manager: *"It would certainly be good to be able to control the column better."*

The risk analysis help to establish the causal relations between the production processes, the pollutants, and their flow to the sewage system. In doing, it focuses the managers' attention on what things should be corrected. Based on the collective work carried out to analyze risks and gain a better understanding of process operation, new parameters and instructions were formally added to workers' manuals. For example, a new instruction based on a new assessment of the risk of equipment leaking or failing, or of the chemical reaction being different, was introduced. Technicians and foremen performed this work and the documents were sent out to the process control operators, who subsequently acted upon these documents.

Towards a common view of incidents

The environment manager decided to calculate more appropriate emission limit values in order to get the company more involved in the dynamics of continuous improvement. The regulations applicable to the site stipulated limit values. However, as these regulations were over eight years old, the reference points offered by the limit values had become obsolete. Over the last few years, the authorities had introduced stricter requirements and the company had agreed to make considerable investments in order to reduce its pollution. The site's aim was to show that it had indeed improved its performance in this area.

We must consider the definition of accidental pollution held by workshop managers, foremen or engineers. For these people, an "accidental" situation corresponded more to equipment failing or leaking. The detector monitoring the equipment immediately identified such events. If the floor of the platform was washed clean by a sudden shower of rain, taking with it all the liquid waste from the last maintenance operation, this was not considered to be an incident. From an environmental point of view, however, such an incident could lead to the new limit values being overstepped hence requiring an analysis of the causes. Operational management needed to build up their own reference points so as not to be the cause of any "accidental pollution" and be branded as polluters.

The environment department therefore wished to introduce new limit values in order to define preventive actions. They used statistical methods well known from quality management. These methods outline a level of "acceptable variability": when the concentration is below the limit value. When it is above the limit value, variability is considered to be "accidental" and the cause of pollution has to be located. These values were modulated in order to take into account various concerns, such as focusing effort on critical pollutants and anticipating new regulatory requirements. Using these calculations, the environment department was able to build up a new, more appropriate definition of the limit values.

The production managers asked for a simulation to be carried out using the limit values in order to assess the workload required to perform corrective action. Based on the results of this simulation, the site manager asked for limit values to be recalculated. In this way, the production team's objectives of knowing how much of their workload would be dedicated to the environment had an effect on the definition of the limit values. It was agreed that these values should be regularly reviewed in order to take performance improvements into account. It was only through a long learning process and the many discussions that took place every time the limit values were exceeded that the operational managers were able to establish their own reference points.

In this limit value calculation, we can observe two processes that rely on each other: the production of knowledge (about the variability of pollution) and the mobilization of actors. Producing knowledge actually helps to mobilize people: new limit values are accepted as a shared definition of what is acceptable or not, at which point in time the definition was no longer controversial.

Negotiating, formalizing and getting around rules

Implementing ISO14001 entail a great deal of work to formalize organizational rules and define responsibilities. This section focuses on the links between managerial strategies aiming to control behaviour and the cooperation strategies targeting the production and circulation of knowledge.

Negotiating new formal rules

As documents were formalized and management tools set up, and the EMS became a reality, those involved gradually adopted the roles that they had helped to define. For accidental pollution prevention, a procedure defined the conditions according to which the environment function was to delegate the search for the source of pollution to the production staff. All these new roles were the result of numerous discussions and negotiations. Drawing up formalized procedures was also a means for the production staff to justify their own practices for locating the source of pollution by: contacting other teams, visiting them for information about current operations, visiting installations and, when really necessary, analyzing pollutants in the sewage network. A number of new technical instruments helped to determine the roles to be played by each team in the pollution research process. A sampling system was placed in the sewers in the middle of the factory. Based on the detection of pollutants downstream, this system determined which part of the factory was concerned and which team responsible for the search. Hence, this technical instrument helped to stabilize the other actors' roles.

The prevention of accidental pollution can serve as another example. This was mainly based on extending the use of an "incident report" form. For the environment manager, the aim of introducing this reporting system was to increase cooperation with the production staff in identifying sources of accidental pollution and in the setting up of preventive actions. For the production staff, the system helped them identify potential crisis situations so that repeated accidental pollution could be avoided. The system was therefore drafted jointly and defined the procedures that each function should undertake: the environment department was officially in charge of signalling the incident requiring corrective and preventive actions while it was the operational manager concerned who was responsible for organising these actions.

The implementation of ISO 14001 helps therefore to develop organization. It provided the company managers with an opportunity to describe current practices (for example how to locate incidents) and emphasize their importance, while simultaneously allowing them to expand upon the well known (quality measures) to develop new practices, which, thanks to shared knowledge of the working conditions and negotiation of working roles, are better accepted.

Regulating practices around and beyond formal rules

If the Incident Report is put back in context, one can see that it is not without ambiguity. Of course, it was designed for the purpose of continuous improvement: to encourage operational managers to undertake improvements in each risk-related situation. The chemical plant's operational managers could use the Incident Report to outline their ability to improve performance in the workshop. However, the Incident Report also acted as a two-edged sword.

In a managerial context, where monitoring is an important issue, the Incident Report appeared to be particularly threatening for production operators and foremen. To begin with, these employees saw the limit values as being entirely arbitrary: their calculation was based on statistics and, owing to a lack of knowledge about the cause of emission, the production teams did not necessarily know how to comply with them. Secondly, the Incident Report required a systematic analysis of the causes. Its use entailed revealing practices that it would have been better not to disclose. Finally, the Incident Report required incidents to be reported in writing. Such written reporting made the review of practices more formal. Written reporting points to individual responsibilities and crystallizes judgements.

So as not to be found at fault, the foremen and members of the environment department discovered a way to get around these procedures. They simply chose to leavethe cause analysis section blank or not fill in the document. The environment team members quickly realized that it would be better to visit the operational managers and talk things through with them rather than keep their distance with these reports. They tried to avoid referring to responsibilities and faults and strove to keep things technical by focusing on causal knowledge and reducing operational problems. This attitude tended to boost the confidence of the operational managers and facilitated an oral transfer of information.

This account shows the dual nature of management tools: they can produce knowledge and control behaviour, but only to a certain extent. It is always possible, when using these instruments, to underline or undermine one or other of these dimensions. In the example above the choice was to privilege feedback and the spread of knowledge since, without this knowledge, no action would have been possible. The environment department needed to increase its knowledge of operational problems in order to strengthen its legitimacy, its ability to put forward proposals and its power over incentive and control. The Incident Report, although not used as planned, enabled a tacit agreement (Friedberg 1993) to be set up between the environment department and the production teams: the environment department authorized the non use of the form in exchange for an in-depth oral discussion. This device helped to mobilize the production teams, even if the formal procedures were sidestepped.

Discussion

The implementation of ISO 14001 is not an easy matter. The organizational dynamics associated with the standard can go far beyond the contents of the actual standard document. The extent of its implementation depends on the processes by which members of the company apply the standard's generic models and give them meaning. Industrial organizations are not virgin territories on which one simply builds up an environmental management system from scratch. They already have certain routines or modes of internal management, quality management and environmental management practices that introducing a new system challenges because of the uncertainty as to future work practices, cost structures, and ultimately profits. Existing routines are 'recycled' and re-interpreted with respect to the requirements of ISO 14001 in the same way that the standard is re-interpreted with respect to these practices.

Environment managers are likely to have aspirations for the setting up of ISO 14001, but are equally likely to face organizational and technical problems. In response, they have to develop a sharp awareness of the transformations needed so that they might apply to mobilize others in the organization. To this end, they use a host of intermediaries (Callon 1986) – literary inscriptions such as the Incident Report, all the technical artefacts that can measure the pollutants, their colleagues in other departments and the necessary funding of all the procedural changes. Even more so than for quality, integrating environmental concerns creates tension between the environment department, as it attempts to introduce new requirements, and the other departments who are already subject to a whole range of contradictory constraints. Having observed the daily life of an environment department and its relations with the other departments, I understood that integrated techniques and continuous improvement suffer from the division of work and competence between the environment function and the engineering and production functions. This division of work means that the environment manager is highly dependent on the other company's functions. The environment department needs to be sufficiently familiar with production activities to be able to transpose its own requirements on to these activities. Analyzing the environmental managers' behaviour in terms of the existing division of work and work routines rather than in terms of management imperatives opens up for studying the interaction of different groups within an organization and the interaction of different – in this case – engineering cultures, i.e. between the environmentally informed and the more conventional production oriented engineering culture. The research behind this article underlines the advantage of building up a detailed understanding of the situations in which production managers have to act, torn as they are between the contradictory injunctions of different functional departments and the production teams whose buy-in is not always easy to obtain.

The new knowledge shared between the production, engineering or environment departments constitutes a common foundation on which it is possible to rethink the entire range of activities and process operations. Taking into account the complexity of environmental issues, the way these are spread throughout the organization and collectively investigating them is a pre-requisite to defining solutions and responsibilities. Similarly, the production of knowledge creates a new, shared view of the industrial process with respect to the environment. This shared view is also political since it favors the strategic intentions of the environment department and helps to redirect the behavior of the other people involved. This result can also be generalized: I have observed, in this case, but also in other industrial plants that the lack of shared knowledge between environment and production staff produces misunderstandings and paralyzes collective action, problem resolution, and mobilization, especially as the complexity of the socio-technical system increases. This case stresses the idea that knowledge development and power relations are closely linked: the management instruments that have been described in this article reduce the dependency (Friedberg 1986) of the environment manager on production staff and make production staff's behavior less uncertain. The environment manager acquired part of the knowledge he needed in order to understand and gain better control of the production activities.

However, the case shows that the formally established instruments are not always capable of building up a shared view and a formal organization: the rationalization process can be incomplete because of the socio-technical complexity. The heterogeneous nature of experience and knowledge cannot always be sidestepped, owing to the distance between situations (Suchman 1987, Brown and Duguid 2001). In this case, the definition of new concentration limit values for emissions from the chemical plant brought to light the fact that the production teams had a different view of accidental pollution. Transforming their view required frequent informal information exchanges to allow for the alignment of different views. The instruments were relayed by relatively formal, cross-functional working groups who took over the "translation" process by assimilating as many of the specific characteristics of each action context as possible, thus, allowing for increased coordination. Finally, in this case, the enrolment strategies, founded on the production and circulation of knowledge, led to the abandonment of more conventional managerial strategies for controlling behaviour based on rules and formal indicators. Indeed, the production of shared knowledge sometimes requires strong cooperation and is not very compatible with an overly authoritative or distant attitude. Here, the environment department preferred to adopt an understanding and cooperative attitude. New, stricter rules were certainly formalized, but the members of the environment department preferred to sidestep them. These rules helped to define a new, common context for action in which the various people involved set up tacit agreements to continue to progress in their knowledge of the process and practices.

What lessons can we draw from this account of the positive effect on environmental integration of an understanding and cooperative attitude, a certain distance towards formal rules, and the development of tacit agreements regarding environmental issues? One answer would be to cast this in terms of power and strategic action or, as is more commonplace, the lack of power. Another answer would cast this as a matter of the environmental department's social skills. However, both of these answers overlook the work and authorship involved in introducing, altering and circulating different technical and literary artefacts (e.g. reports) necessary to come to an agreement. Third, the above-mentioned developments could be interpreted as the result of French culture and French attitude towards formal rules and the importance of tacit arrangements. However cultural interpretations have been contradicted by different comparative studies (Friedberg, 2005) and it seems that organizational factors, such as the way prescriptions are maintained, the ways in which the work between prescription and execution is divided, and as the ways prescriptions are accepted or not by different professional cultures play an equally if not more important role than national culture. Also, the tacit arrangements I observed are very different from the tacit arrangements usually described in national culture comparatives studies: here, they contribute to transparency and cooperation and not to opacity and distance.

Conclusion

This article reports on the implementation of ISO 14001 as a process of organizational change as co-constructed by the various members of an organization. Organizational change depends on the strategies adopted by the employees, on their need to improve coordination and on their willingness to cooperate. Particular emphasis was placed on how the implementation of ISO 14001 reduced the dependency of the environment department on the other company departments, increased its ability to control and encourage other departments to engage in environmental management. This was achieved through the production and circulation of a host of artifacts embodying extensive knowledge about the production activity and its impacts on the environment. The learning process can thus be seen as a condition for mobilizing teams around the environmental stakes.

There are several conditions required for successful ISO 14001 implementation (an implementation that contributes to environmental performance improvement). The first condition has to do with the strategic skills of the environmental manager – s/he needs to provide meaning to the project, assess the internal political context and negotiate how to define and apply formal rules. The second condition relates to the industrial management culture shared by all the members of the organization. This condition must cover both tools and procedures, the language used to describe and formalize, the methods implemented to, for example, run a problem-solving group. The chemical plant proved to have real expertise in the drafting of procedures and working documents, especially when it came to cross-functional processes. The third condition relates to the ability to set up suitable instruments for pooling technical knowledge and translating environmental requirements into operational objectives. In sum, the translation of environmental requirements into everyday work practices is conditioned by socio-technical complexity and organizational partitioning.

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Risk calculation	**Knowledge**	**Actors concerned**
Probability of failure	Knowledge of past failures and equipment's weak points	Production staff
Consequences in terms of pollutant quantities	Representation of processes contributing to the risk of pollution, knowledge of treatment equipment's ability to deal with accidental pollution	Production staff and process engineers
Evaluation of the pollution level	Knowledge about regulations and environmental effects (irreversibility), impacts in terms of image	Environment Staff

Table 1. Risk calculation: Knowledge and actors mobilized.