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Application of the Method of Organizational Congruencies in Substituting Organic Solvents With Vegetable Agents for the Cleaning of an Offset Printing Machine

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NOTES

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The aim of this research is the application of the Method of Organizational Congruencies before and after the substitution of organic solvents with vegetable agents for the cleaning of an offset printing machine in order to assess the organizational changes. A solvent-free process is the goal of the Subsprint Project (Technology Transfer Program of the European Community). This study shows how human and environmental health is improved by using vegetable agents, though this change may lead to some other organizational constraints such as an increase of the time needed, monotony, and repetitiveness of the technical actions involved. The authors underline that the knowledge of the impact of the new technology on health helps a better understanding of the resistance to the change and its further amelioration.

organic solvents organization offset printing health substitution vegetable agents

1. INTRODUCTION

Organic solvents are used in industry to extract, dissolve, or suspend insoluble materials in water, such as fats, resins, polymers, or other substances. Their use has been correlated to many toxicological effects on human health and the atmospheric

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environment. Both long and short term exposure to organic solvents may cause health damage. Acute effects are irritation of the skin, eyes, and upper respiratory ways. Typical symptoms are headache, dizziness, nausea, tiredness, apathy, and—in the case of high exposure—unconsciousness. Chronic effects are mostly due to suspected or proved carcinogenicity or teratogenicity. Allergenic effects and central nervous system (CNS) disorders are more frequent. Many diseases of CNS are caused by exposure to organic solvents such as polyneuropathies and the psychorganic syndrome (Gennard & Lauwerys, 1990).

Environmental pollution is caused by residual organic solvents in the air (1% of the overall emission of organic solvents in Europe is caused by the cleaning of offset printing machines) and water; some of these solvents may affect the ozone layer. Finally, they may produce fires and explosions because of their high level of inflammability (Printing Industry Advisory Committee, 1986). Therefore, replacing them is desirable in all industrial processes to improve human and environmental health (Dalton, 1993; Goldschmidt, 1993; Maranelli et al., 1992). Only recently organic solvents have been partially substituted with terpeni (mostly d-limonene) but these chemical agents are showing high allergenic effects (Karlberg, Shao, Nilsson, Gafvert, & Nilsson, 1994). New agents such as vegetable agents are then a true hope as shown by the Danish experience (Sorrensen & Petersen, 1994).

Subsprint (Technology Transfer Program of the European Community) Project is aimed at substituting organic solvents in the cleaning of offset printing machines with a solvent-free cleaning process (Ciani Passeri, Scarpelli, Tartaglia, & Carnevale, 1994; Parting & Steendahl, 1992; Subsprint Project, 1993).

Each substitution comes from an organizational change. This change may involve not only the use of chemical agents but also the working process, equipment, human relations, and so forth. Therefore, it is important to assess those changes that may be the reasons for lack of improvement. Human habits are difficult to change even if there is an improvement in health (Carnevale, Banchi, Ciani Passeri, & Scarpelli, 1994).

This study is aimed at assessing the organizational changes resulting from substituting organic solvents with vegetable agents. The Method of Organizational Congruencies (MOC) developed for analysing organized situations was used (Maggi, 1990). The various organizational constraints present when cleaning an offset printing machine with organic solvents and with vegetable agents are shown. This method was even used to assess other technological changes, such as tile production (Salerno & Guglielmino, 1990) and electronic metal-turning (Tartaglia, Salerno, Bernetti, & Carnevale, 1991).

2. METHODS

The Method of Organizational Congruencies (MOC) for studying the relationships between organized work and well-being is used (Maggi, 1990; Maggi & Grieco, 1986). This method has been a well-known and tested instrument for organizational analysis in various Italian research areas (Cristofolini, 1990; Rulli et al., 1995) for more than a decade. It allows identifying those Organizational Constraints that

constitute restrictive conditions deriving from organizational choices (and as such should be modified).

The MOC is an operative instrument developed by interdisciplinary research derived from a specific epistemological choice (the idea of organization as a process of choices, decisions, and actions oriented in a rational and limited way towards desired outcomes) and a theoretical choice (Theory of Organizational Action).

The organizational constraints are the link between interdisciplinary knowledge on organized work and interdisciplinary knowledge on human health. The definition of health adopted by the Interdisciplinary Research Group on Organization and Well-Being is health as a process and work as an organizational process.

The MOC allows us to analyze and evaluate the relationships among the *desired outcomes* (goals of the process), the *structure of technical actions* (technical actions and relationships independent of the workers involved), the *social structure* (participants carrying out the technical actions, places, ways, times, and workers' involvement in the performance), the *technical knowledge* (the knowledge of the object to be transformed, of the means and tools for the transformation, and the transformation process). This procedure leads to the identification of the *Organizational Constraints* (OC) deriving from the ties, variabilities, and incongruencies of the organizational action. The description details of organized work may vary according to the depth of the analysis to be carried out. The OC evidence the reduction in decision ranges and the individual freedom unavoidably induced by each organizational choice. The OC, from a biomedical point of view, are conditions of endangering physical, mental, and social well-being; nevertheless, the organizational action has constraints before and beyond the risk conditions in the workplace.

The biomedical analysis evaluates possibilities and probabilities that the OC (conditions of danger) lead to risks and psychophysical social discomfort at individual or at group level. If the thresholds of tolerance and balance are overcome, we have real suffering or illness.

Table 1 shows a description and analysis with the MOC. The first three columns describe the work situation, the fourth column lists the OC, the fifth column lists the risks for well-being that may derive from the identified OC, and the sixth column lists damage identified by a biomedical analysis of the well-being conditions of the workers involved.

Some organizational constraints (condition of danger) allow measurements of the risk level. In other cases, the relationship between exposure to noxious agents and the consequences (and indicators of this exposure) have not been characterized yet. The quantitative measurement of the risk level does not highlight the danger conditions. Such conditions represent a chain of choices, decisions, and actions involving the presence of noxious agents in the work situation inducing limitations in the worker's physical, sensorial, and mental engagement.

The MOC has been used to identify the risk conditions both in the cleaning of an offset printing machine with organic solvents and in the new technique—as proposed by Subsprint—with vegetable agents. Conditions of danger are represented by the presence of organic solvents in the environment; the consequent risks are nervous pathologies due to exposure over a particular level and damage (brain damage).

TABLE 1. The Description of the Analysis With the Method of Organizational Congruencies (MOC)

		Desired Outcomes			
Structure of Technical Actions	**Social Structure**	**Technical Knowledge**	**Organizational Constraints (OC)**	**Risks**	**Damage**
Coordination and control of technical actions:	Coordination and control of individuals:	Technical knowledge:	They represent conditions of danger:	Risks for workers' well-being:	Damage:
Technical actions and their relationships (independent of involved participants).	Assignment of technical actions, places, times, ways, involvement in the performance.	Required to reach the desired outcomes, and related to the object and means and tools of process transformation.	Deriving from ties, variabilities, and incongruencies among the different levels of the organizational action. They may lead to risks for workers' well-being.	Defined by an interdisciplinary biomedical evaluation of the OC. They can be measurable or not.	Signs or diseases identified in the involved participants.

The study was performed at the Leonardo da Vinci Technical Institute in Florence, including a printing laboratory for training students in printing processes. The MOC was applied at a working stage involving a single-colour printing machine (35 × 50) with a traditional bath, using red ink, with a maximum production of 10,000 copies per hour, made in Czechoslovakia in 1990. The chemical agents used for organic solvent cleaning were a mixture of petroleum compounds and a lemon compound called d-limonene (terpene). To evaluate environmental exposure to organic solvents, we measured total hydrocarbon concentration derived from petroleum compounds during cleaning by using ink rollers. Then, a gas chromatographic analysis of air samples was performed. Our reference for TLV (Threshold Limit Value) was 350 mg/m^3 (total naphthas), that is, the NIOSH (National Institute for Occupational Safety and Health) criterion for a naphtha mixture with less than 20% of aromatic hydrocarbons (Dean et al., 1991).

Soya oils were the vegetable agents used for a solvent-free cleaning process. There was no environmental exposure to soya oils, because the soya oils were kept within the cloths during the cleaning.

3. RESULTS

The printing process sequence is photocomposition, type settings, platemaking, offset printing, finishing, and packing. Organic solvents are mostly used in the fourth stage for cleaning the offset printing machine. The cleaning stage consists of cleaning the ink rollers, the rubber blankets, and the ink fountain. This action is necessary in order to change the ink colour for new colour printing or after a day's work. Cleaning accuracy depends on the printing colour that is going to be used next (e.g., yellow versus black, or vice versa).

During cleaning with organic solvents, we measured an environmental exposure of 32.6 mg/m^3 (range 13.4–59.7) and a higher individual exposure of 34.5 mg/m^3 (range 10.9–74). The results show that there is environmental pollution in the workplace even if it is below the NIOSH TLV. There is no environmental pollution when using soya oil.

Table 2 shows the results of the application of MOC in cleaning with organic solvents. **Table 3** shows the results of the application of MOC in cleaning with vegetable agents.

4. DISCUSSION

We have described the work in cleaning an offset printing machine with organic solvents as compared with vegetable agents.

The desired outcomes of the two processes differ. Cleaning with organic solvents has the goal of just cleaning; cleaning with vegetable agents is cleaning taking into account human and environmental health.

In cleaning with vegetable agents four technical actions are added on account of water use. This leads to an increase of 2 min and 52 sec in the cleaning time

TABLE 2. Cleaning Offset Printing Machine With Organic Solvents (•)

Structure of Technical Actions	Social Structure	Technical Knowledge Needed	Organizational Constraints (OC)
1. Applying organic solvents to ink rollers	After the machine start, the operator goes up on a little wooden box in order to apply organic solvents from a plastic bottle. Length: 5 s	– Organic solvents and machinery – Hand container – Cleaning of the ink rollers, printing stages	• Organic solvent vapours • Noise caused by machinery • Incorrect posture (standing on a wooden box) • Risk condition for an accident (falling off the wooden box) • Simple action requiring attention
1. 1. Automatic cleaning	The operator turns on the switch of the automatic cleaning printing machine. In the case of insufficient cleaning, he applies another organic solvent. To do that, he has to remove the carter in a poorly lit place. Cleaning speed: 8000 turns per minute. Length: 2 min 20 s	– Automatic cleaning machinery – Switch – Automatic cleaning of the ink rollers, printing stage	• Organic solvent vapours • Noise caused by machinery • Insufficient light and consequent difficulty in checking the cleaning • Simple action requiring attention
2. Hand cleaning of printing plate with terpene	The operator cleans the printing plate with a cloth soaked in terpene using his gloved right hand. At the same time, with his left hand, he turns on the printing plate switch in order to clean the whole surface. Length: 53 s	– Printing plate and terpene – Hand cloth soaked in terpene – Cleaning printing plate with terpene, printing stage	• Irritative and allergenic effect on skin and mucosa • Muscular load for right arm • Simple action requiring attention • Use of gloved right hand
3. Hand cleaning of the rubber blankets with organic solvents	The operator cleans the rubber blankets with a cloth soaked in organic solvents. At the same time, he turns on the rubber blanket switch in order to clean the whole surface. Length: 50 s	– Rubber blankets and organic solvents – Hand cloth soaked in organic solvents – Cleaning with organic solvents, printing stage	• Organic solvent vapours • Use of gloved right hand • Muscular load for right arm • Risk condition for right hand due to machinery movement • Simple action requiring attention
4. Hand cleaning of the ink fountain with organic solvents	The operators empties the ink fountain with a flat trowel. To do that, he goes up on a little wooden box. He cleans the ink fountain with a cloth soaked in organic solvents. Then he dries the ink fountain with a clean dry cloth. Length: 2 min	– Ink fountain and organic solvents – Hand cloth soaked in organic solvents – Hand cleaning with organic solvents, printing stage	• Organic solvent vapours • Use of gloved right hand • Muscular load for right arm • Incorrect posture (standing on a wooden box) • Risk condition for an accident (falling off a wooden box) • Simple action requiring attention

Notes. •—The Organizational Constrains (OC) represented by monotony and loneliness have been pointed out in all the cleaning stages. Govern, verification, and regulation: the printer operator. Overall length of the cleaning stage with organic solvents: 6 min and 8 s.

TABLE 3. Cleaning Offset Printing Machine with Vegetable Cleaning Agents (•)

Structure of Technical Actions	Social Structure	Technical Knowledge Needed	Organizational Constraints (OC)
1	2	3	4
1. Applying vegetable agents on ink rollers	After the machine start, the operator goes up on a little wooden box in order to apply some vegetable agents on the ink rollers from a plastic bottle. Length: 15 s	– Vegetable agents and machinery – Hand plastic bottle – Hand cleaning with vegetable agents, printing stage	• Noise caused by machinery • Incorrect posture (standing on a wooden box) • Risk condition for an accident (falling off a wooden box) • Simple action requiring attention
1. 1. Automatic cleaning	The operator turns on the switch of the automatic cleaning of the printing machine. In the case of insufficient cleaning, he applies other vegetable agents. To do that, he has to remove the carter of the machine in a poorly locally lit place. Cleaning speed: 8000 turns per minute. Length: 3 min	– Automatic cleaning machinery – Switch – Automatic cleaning of the ink rollers, printing stage	• Noise caused by machinery • Incorrect posture (standing on a wooden box) • Insufficient light and consequent difficulty in checking the cleaning • Simple action requiring attention
1. 2. Removal of vegetable agents	The operator rinses the ink rollers with water 2–3 times using an atomizer plastic bottle in order to remove all the residual vegetable agents. Length: 10 s	– Printing plate – Vegetable agents – Hand atomizer plastic bottle – Hand cleaning ink rollers with water, printing stage with vegetable agents	• Simple action requiring attention • Incorrect posture (standing on a wooden box)
2. Hand cleaning of the printing plate with vegetable agents	The operator cleans the printing plate with a cloth soaked in vegetable agents. He applies them with his right hand in a rubber glove. At the same time, with his left hand he turns on the printing plate switch in order to move it and clean the whole surface. Length: 30 s	– Printing plate and vegetable agents – Hand cloth soaked in vegetable agents – Cleaning the printing plate with vegetable agents, printing stage with vegetable agents	• Muscular load for right arm • Use of gloved right hand • Risk condition for an accident involving the right hand • Simple action requiring attention

Structure of Technical Actions	Social Structure	Technical Knowledge Needed	Organizational Constraints (OC)
1	2	3	4
2. 1. Hand cleaning of the printing plate with water	The operator cleans the printing plate with a wet cloth using his right hand. At the same time, he turns on the printing plate switch with his left hand in order to clean the whole printing plate surface. Length: 35 s	– Printing plate and water – Hand cloth with water – Hand cleaning of printing plate with water, printing stage with vegetable agents	• Use of gloved right hand • Muscular load for right arm • Risk condition for an accident involving the right hand • Simple action requiring attention
3. Hand cleaning of the rubber blankets with vegetable agents	The operator cleans the rubber blankets using a cloth soaked in vegetable agents. At the same time, he turns on the rubber blanket switch with his left hand in order to clean the whole printing plate surface. Length: 40 s	– Rubber blankets – Hand cloth soaked in vegetable agents – Cleaning of rubber blankets	• Use of gloved right hand • Muscular load for right arm • Risk condition for right arm • Simple action requiring attention
3. 1. Hand cleaning of the rubber blankets with water	The operator cleans the rubber blankets with a wet cloth and then with a dry cloth. At the same time, he turns on the rubber blanket switch with his left hand to clean the whole surface. Length: 50 s	– Rubber blankets, water – Hand wet cloth – Hand cleaning of rubber blankets with vegetable agents, printing phase with vegetable agents	• Use of gloved right hand • Muscular load for right arm • Risk condition for right hand • Simple action requiring attention
4. Hand cleaning of the ink fountain with vegetable agents	The operator empties the ink fountain with a flat trowel. He cleans the ink fountain with a cloth soaked in vegetable agents. He waits until they have been absorbed, then he distributes the vegetables agents over the ink conductor and knife. Length: 2 min	– Ink fountain, vegetable agents – Hand cloth soaked in vegetable agents – Hand cleaning with vegetable agents, printing phase	• Use of gloved right hand • Incorrect posture (standing on a wooden box) • Risk condition for an accident (falling off a wooden box) • Muscular load for right arm • Simple action requiring attention
4. 1. Hand cleaning of the ink fountain with water	The operator cleans the ink fountain with a wet cloth to remove residual vegetable agents. Length: 1 min	– Ink fountain, water – Hand cloth with water – Hand cleaning of the ink fountain	• Use of gloved right hand • Incorrect posture (standing on a wooden box) • Muscular load for right arm • Simple action requiring attention

Notes. •—The Organizational Constrains (OC) represented by monotony and loneliness have been pointed out in all the cleaning stages. Govern, verification, and regulation: the printer operator. Overall length of the cleaning stage with organic solvents: 9 min.

required. This difference may cause some problems for improving this technique. We then compared the organizational constraints (OC) in the two different cleaning process sequences. It can be seen that, using vegetable agents, the exposure to organic solvents and its environmental consequences disappear, thus highly contributing to human health, environmental impact, economic saving.

There are, nevertheless, some problems due to this organizational change. The substitution of the hazardous chemicals shows, in our case, an organizational change with an increase of simple technical actions demanding attention, of cyclical actions with monotony and repetitiveness with an increase of understimulation as shown by Hans Selye's theory of stress (Selye, 1976). The results also show an increase in the amount of technical actions involving muscular load for the right arm to be studied with a posture analysis (Colombini et al., 1985). Other organizational constraints are still common to the two techniques such as loneliness, noise, incorrect posture, risk condition for an accident involving the right hand.

Thus, further studies are needed to reduce all the organizational constraints still existing, though we are conscious that each new organizational choice involves new problems to be faced. The MOC gives an important contribution in assessing environmental and health problems in view of finding new solutions.

5. CONCLUSIONS

The substitution of chemicals in the working environment is an organizational process involving all the participants: workers, employers, managers, scientists, local health unit officers, and so forth. Each substitution has to face some behavioural resistance, which is an additional reason for requiring clear goals, good interdisciplinary analytical methods, interdisciplinary experts, good information, and good evaluation of the results.

An interdisciplinary approach to the solutions and improvement measures at work need an overall view requiring also an economic evaluation. In this regard it should be underlined that the cost of lack of health is often unknown.

The experience on chronic toxic encephalopathy in Denmark is a good example. Workers' brain damage was unknown and underestimated until it was discovered; all costs were clear (Sorrensen & Petersen, 1994). The same holds for atmospheric pollution due to organic solvents and its costs. For instance, the use of vegetable agents in the automatic cleaning of an offset printing machine is a way of improving the environment. Environmental pollution due to organic solvents (Volatile Organic Compounds) is very high, and each step towards solvent-free processes is a step towards ecology and health for all.

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