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THE RELATIONSHIP BETWEEN CONSTRUCTION CONTRACTORS AND THEIR CLIENTS IN PETROCHEMICAL AND RELATED INDUSTRIES

STEFÁN EINARSSON[1]
Department of Production and Quality Engineering,
Norwegian University of Science and Technology
N-7034 Trondheim, Norway

ABSTRACT

The construction industry has higher accident rates than normal manufacturing. Very high accident rates were found amongst contractors in parts of the Norwegian offshore industry. The term contractor includes individual workers, small firms, and large construction companies with many employees. The contractor is exposed to process risks and diverse occupational risks while doing maintenance or construction work. Clients have legal obligations to inspect contractors' safety performance. They are also accountable for contractors' accidents. A certain model used in the Norwegian offshore industry for managing contractor safety, the integration model, was developed from quality management principles. Contractors are hired for short-term and long-term construction projects, and during this time their safety programs are reviewed and adapted to the programs of clients. Results from American studies have shown many structural problems within the contractor-client relationship. This paper attempts to describe the main problems of contracting from a broad perspective, attempting to bring up relevant safety practices in construction with a view toward construction contractors in petrochemical and related industries.

1. INTRODUCTION

Contracting was a popular form of putting out jobs to individuals in the old days. The aim was to use lower skills and get a good price on the work. The same principle is applied today. However, today the concept of contractor is mainly applied to a multi-skilled organisation that can be engaged in certain activities, for instance, on the construction site. The organisation may need engineers, carpenters, plumbers and electricians to do the work assignments. The contractor may do only part of a job, like the fill for a road, or an entire job, like building a road or raising and finishing a whole building, all by himself. In large and complicated projects, like construction of an airport, clients may hire many contractors. Contractors may again hire subcontractors to perform parts of the project. Subcontractors may again use other subcontractors to do part of their job, and so on. The smallest entity may be a single man skilled in a trade and who is linked with a subcontractor or a contractor.

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[1] Ph.D.student presently at the Engineering Research Institute, University of Iceland, Hjardarhagi 2-6, 107 Reykjavik Iceland

The client wants to control the quality of his property while it is being built or maintained. He is obliged to control safety according to the law. This may not be an easy task since a large construction site may become crowded with contractors' employees. Everyone is supposed to work fast and efficiently. Several contractors may be working at the same time for the same client, which calls for efficient co-ordination on behalf of the client. This reality makes it difficult for the client to control the work process entirely, especially on large projects. These problems may be complicated by other situational problems. Many workers have to stay away from their homes for a long time and often live in low-quality quarters. Often people of different nationalities and cultures are thrown together for long periods. Drug and alcohol problems are not rare. Social problems can have a high impact on safety culture at the construction site. This may also lead to an increased risk of accidents.

Construction activities increase during economic upswings. Many people, a lot of them unskilled, are hired in the construction industry in good times. This may result in an increased number of accidents, which normally is high already. Table 1 compares the frequency of accidents in construction and manufacturing. It is obvious that the accident frequency in construction (Helander, 1991) is much higher than in manufacturing.

Table 1
Frequency (per 100,000 employees) of major injuries to parts of the body for accidents in construction (n = 2239) and manufacturing (n = 4743) in UK in 1985.

Body part	**Construction**	**Manufacturing**
Face	13.5	6.2
Head	12.2	3.0
Back and trunk	35.9	9.4
Hand and finger	21.4	25.8
Arm and shoulder	33.6	14.7
Foot and ankle	21.7	7.5
Leg	40.0	13.3
Other	106.5	12.4
Total	*225.7*	*92.3*

Source: (Helander, 1991)

During economic downturns, many loose their jobs, and the pressure on the remaining labour force increases.

The branch's morale has been characterised as special. The reason may be that hard competition exists amongst contractors, and profit margins are low. The situation of construction workers is different from that of workers in other industries. Employment is often temporary, and workers complain about hurried time schedules for tasks (Niskanen, 1993). Tasks are physically and psychologically difficult, and the turnover rate of employees is sometimes high. Contractors may not receive any warning about hazards created by other contractors. This leads to difficulties in planning.

Table 2 shows fatal accident rates in diverse trades. Building and construction have higher than average FAR-values. Falling accidents, overexertion or strenuous movement and handling accidents are characteristic for the construction industry. In addition, construction workers are struck by falling and flying objects, and they come into contact with moving objects and machine parts (Helander, 1991).

Table 2
"Fatal accidents at work. Fatal accidents in the Nordic countries over a 10-year period." The Danish Working Environment Service, Copenhagen, Denmark, 1993

Industry	**FAR-value**
Agriculture, forestry, fishing, hunting	6.1
Raw material extraction (onshore)	10.5
Industry, manufacturing	2.0
Electric, gas and water supply	5.0
Building and construction	5.0
Trade, restaurants and hotel business	1.1
Transport, post, telecommunication	3.5
Banking and insurance	0.7
Private and public service	0.6
Total (average)	*2.0*

These accident statistics should raise interests for safety in construction and the reasons for the attention paid to contractors, are the high accident rate among contractors in offshore industries. Claims were made that the rate might be nearly six times higher than that for regular workers (Riyamy and Saratory, 1994).

Contractor safety has been in the focus of attention in America for serious reasons. Large-scale accidents have occurred, involving many fatalities and severe losses. One of the most serious accidents was the explosion and fire at the Phillips 66 Houston Chemical complex in Pasadena, Texas on October 23, 1989, where over 20 contract workers were killed. This accident lead OSHA[2] to focus on contractor safety and issue a general report related to the petrochemical industry in the USA (John Gray Institute, 1991). The study listed the reasons for the use of contract labour. Plant managers are advised to take into account: 1) the greater flexibility provided by contractors in matching labour to workload, 2) costs considerations, and 3) union avoidance.

The substitution of non-union contract workers for union direct-hire workers was the most commonly observed pattern. No similar patterns have been observed in the Norwegian offshore industry. The American report is considered very useful in shedding light on many problems within contracting that are focused in the present paper.

The American report makes special studies of safety management practices and of the relationship between contractor and client. This relationship has been formalised in recent years through national and international legislation and new practices in safety management within the companies.

Most legislation, for example, in Norway, other European countries and the USA, aims at increasing the responsibility of clients in securing safety in the building process from the briefing phase to the final inspection. The transactions between clients and contractors in the different building phases, such as briefing, design, tendering, construction and final inspection, become interesting when the problem is viewed as a whole. Contractors and clients are two systems. The systems are disjunctive, but the interface between them has been described as being untransparent or as a muddy responsibility interface (Booth, 1992)

This paper attempts to present and illustrate an overview of organisational safety problems that arise between contractors and clients during the contract period. The problem is described and analysed by

[2] Occupational Safety and Health Administration

looking at past methods of safety management and today's approaches. Examples are given from both Norway and the USA. The problem has many facets since contractors vary in size, and their links with the clients vary, in both the short- and long-term perspectives. This paper deals only with problems that may be considered interesting for safety and safety management in construction generally and construction contracting in petrochemical and related industries specifically. The results and discussion should not be transferred directly to contracting in other sectors of society.

The paper is divided into seven sections. Section 1 is an introduction to the problem of contracting. Section 2 presents the essential elements of structured safety management. Section 3 deals with selection and monitoring of contractors' safety. Section 4 deals with client safety programs. Section 5 deals with contractor incentives to improve their safety. Section 6 deals with the general willingness of clients and contractors to assume risks. Section 7 presents concluding remarks.

2. STRUCTURED SAFETY MANAGEMENT

Contractors in Norway have legal obligations to set up safety management systems. According to the regulation on internal control (IC), every Norwegian company should have a documented IC-system (Hovden, 1995). The Regulation concerning Systematic Health, Environment and Safety Activities at Enterprises ,IC(96), was laid down by Royal Decree of 6 December 1996 and became effective on 1 January 1997. The regulations require the person responsible for an enterprise to ensure that requirements set out in the Working Environment Act, the Pollution Control Act, in legislation on prevention of fires and explosions, the Product Control Act, the Civil Defence Act and the Electrical Installations and Electrical Equipment Act are complied with in a systematic manner. Such systems are called health, safety and environment (HSE) systems, and are defined in the following way:

The HSE-system is the whole of activities, norms (documented and not documented), technical resources, personnel resources and organisational structures that shall contribute to define and comply with goals regarding status of safety, health and environment. The structures and functions can have HSE-management as a primary task (like the organised HSE-committees) or as a secondary task or one of more parallel tasks (for instance maintenance tasks, or supervising) (Tinmannsvik, 1992).

The obligation to maintain internal control also applies to any enterprise that engages independent contractors to carry out construction assignments. Such enterprises must have internal control encompassing the health, safety and environmental requirements imposed on them by virtue of their construction activities and their relationship with the contractors. They are accordingly required to incorporate in their internal control systematic measures to satisfy the requirements of the Regulation concerning Minimum Safety and Health Requirements at Temporary or Mobile Construction Sites (SHR, 1991).

Modelling of safety and quality management systems as a problem solving system shows that the idea of deviation that is corrected within the system is central in the control of safety and quality. In modern contracting both systems are expected to exist within the contractor's company. In reality though only the bigger companies (with more than 50 employees) use both systems. Many smaller contractors may not use those systems.

In Hale's model (Hale et. al, 1997) of safety management systems shown in Figure 1, deviation is shown as a gap between a desired situation and a current situation that needs improvement. Furthermore, it indicates that any solution in safety involves development and activities within a problem-solving cycle (PSC) on different levels within the company. The PSC includes a technical part, an organisational part and a societal part.

Solution of a safety problem involves ethical factors, matters of opinion, where different interests and viewpoints may be elucidated and brought into agreement. Every solution in safety may involve a price that is indirectly put on human lives. The risk of accidents will change as one moves forward in a project; especially the risk between different life phases within a project will not be constant. As usual, those exposed to risk will vary during different project phases.

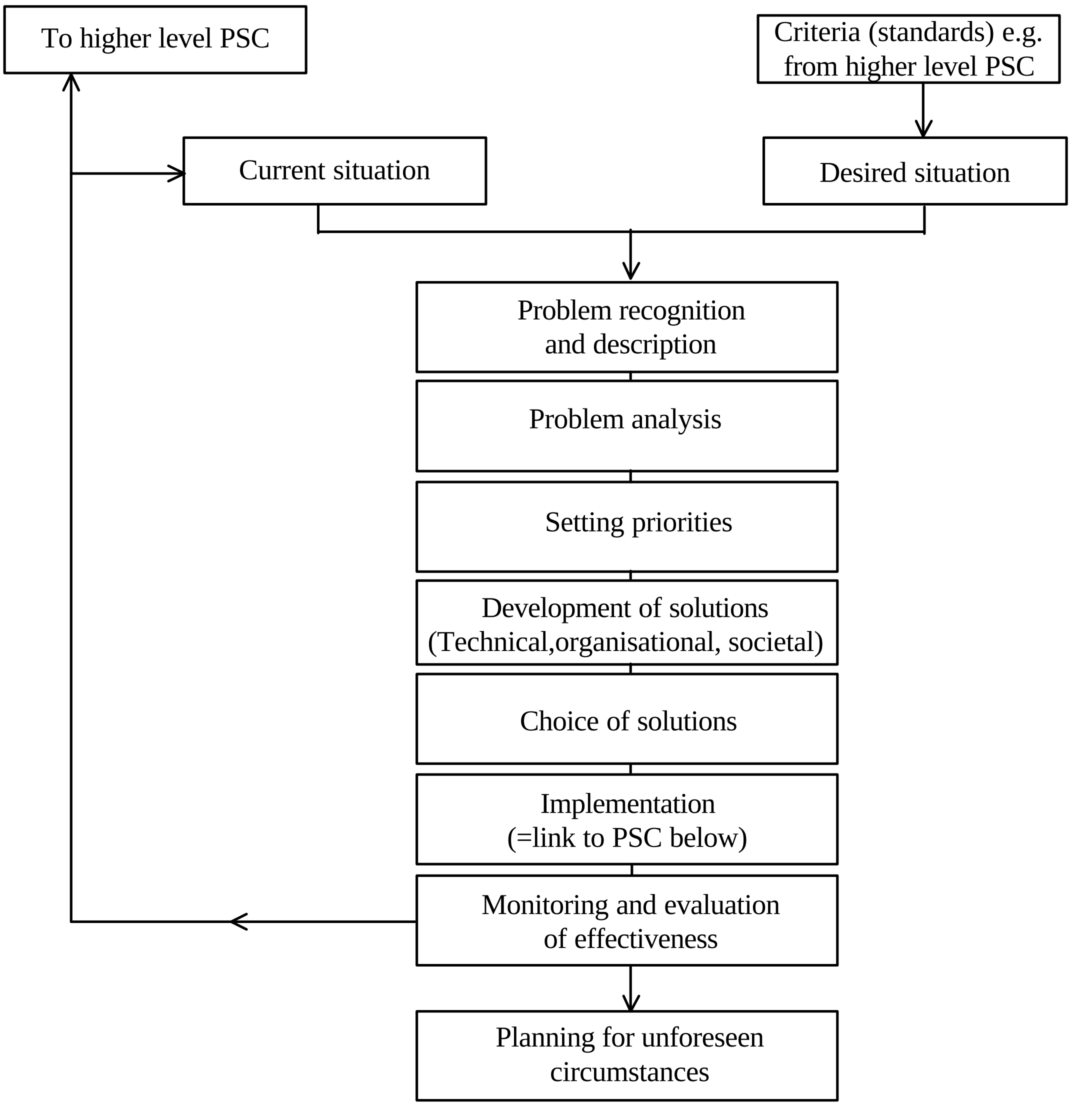

Figure 1 - Model of a safety management system (adapted from Hale et al. 1997)

Each contractor has to deal with risks pertaining to his job assignments. In a new contract, the contractor’s system is usually exposed to a new risk environment. If the environment contains many new risks, it is difficult for the contractor to set the criteria for safety in operations and therefore difficult to control them. This even more if the contractor has no safety program a problem that seems to exist both in the USA and in Norway. This becomes the task of the client in modern contracting.

Interactions within a contractor's company, as well as between contractors and clients, may be shared by other partners, for instance, governmental bodies that become involved in projects considered risky. Risk communication becomes important. If many different safety attitudes cannot converge, the solution to a safety problem may become more affixed to rules. This way is easier than defining deviations in the long run. In some cases, the client may need to support his safety competence with help from governmental bodies. Devotion to safety is only achieved by awareness of tactical, everyday safety management. This awareness is a continuous learning process. The smaller companies may have less structured systems since they often lack qualified personnel and cannot maintain all functions that are needed for efficient work on safety. Scientists claim that a major common problem exists, or that the problem solving cycle shown in Figure 1 does not become activated even if deviations are detected, or that there is inadequate awareness in the pertinent companies.

The client has legal obligations and, by proper activities, shall make up for the deficiencies that may be inherent in the contractor's safety program. Prevention is best if possible. Research indicates that selecting safe contractors and monitoring their safety is an effective practice.

3. SELECTING CONTRACTORS AND MONITORING THEIR SAFETY

In their book on construction safety management, Levitt and Samelson (1987) have made relevant summaries of factual evidence about the safety management of contractors in the US up to 1987. According to them, construction safety will be enhanced if there are procedures in place for selecting contractors and monitoring their safety. Selection is also practised in Norway and especially in the Norwegian offshore industries with related methods.

I Selecting safe contractors

Safety evaluation of prospective contractors has been based upon two kinds of data that are used to estimate future safety performance:

a) Past safety records:

1. EMR, a contractor’s *experience modification rate,* is the ratio of the firm’s actual workers compensation insurance claims costs to its expected workers compensation losses for the company's type of work, averaged over the last 3 to 4 years.
2. OSHA *incidence rates*: number of OSHA-reportable injuries (roughly equivalent to injuries requiring attention by a doctor) per 200,000 working hours. OSHA demands that contractors report this on log sheets each year.
3. References from past clients.

b) The contractor’s current safety practices provide a subjective prediction of its future safety performance. Safety has also been evaluated on the grounds of documented safe practices:

1. Accountability for accidents (supervisors are held accountable for accidents)
2. Safety training (new hires and new supervisors)
3. Formal safety program (written statement from a contractor)
4. Safety meetings (toolbox safety meetings are required by law)

The study on contractor safety in the USA (John Gray Institute, 1991), mentioned above, found a wide range of safety selection criteria, and varying importance was placed on these criteria. In many cases, no formal selection based on safety records was made; in other cases, standard performance measures like OSHA incidence rates and worker's compensation EMRs were used. The findings illustrated an association between rigorous screening practices for contractors and positive safety outcomes. Often, a plant relied on self-reported contractor safety data, and responses to safety questionnaires as safety criteria in screening out contractors were often reported to play a minor role in final contractor selection.

II Monitoring contractor safety

Clients in a study (Levitt and Samelsson, 1987) were asked what methods they used to monitor construction contractors on their projects. Their answers, listed in order of importance, were:

1. Stress safety as part of the contract during pre-job walk-around.
2. Require short-term permits, rather than ongoing permits, for hazardous activities.
3. Conduct safety audits of contractors during construction.
4. Conduct periodic safety inspections.
5. Weigh safety in pre-qualifying contractors for the bid.
6. Require safety training of contractor's employees.
7. Maintain statistics of the contractor’s safety performance.
8. Set goals for construction safety.
9. Include safety guidelines in the contract.
10. Set up a construction safety department to monitor contractor safety.
11. Require immediate reporting of contractor accidents.
12. Discuss safety at client-contractor meetings.

13. Provide contractors with safety guidelines they must follow.
14. Investigate the contractor's accidents.
15. Require the contractor to designate safety responsibility to someone on-site.

Some of these, for example, safety training, may be less significant than others and depend on the circumstances in the trade or at the construction site. However, the responsibility for training contract workers rests with the contractor outside the work area in most plants surveyed in the American study cited above (John Gray Institute, 1991). In the study it is mentioned that the host plant training program consisted largely of presenting a videotape. The case studies showed that the contract workers received less safety training than direct-hire workers did. The contract workers got fewer hours of such training per year, and more than half of them had not received any off-site safety training before starting work at the plant site.

Many of the above mentioned safety activities have become an integral part of client safety programs. The companies in the Norwegian offshore industry have tackled the situation by making special efforts to improve contractor safety. They have both an offshore and an onshore safety program.

4. CLIENT SAFETY PROGRAMS

4.1 Models for managing contractor safety

Safety philosophy, programs and models were developed for managing contractor safety in the Norwegian offshore firms in the 80s and 90s. Basically, the philosophy and programs have been similar in most of the firms. A flow diagram covering the main project phases in the contractor's activities shows how HSE-management of contractors has been integrated into the existing safety management system of the mother firm. This is shown in Figure 2. This integration involves a lot of safety activities. This model was apparently found at one study site in the American study mentioned earlier (John Gray Institute, 1991). Upon hiring, contractors received full integration into the plant's ongoing safety and health skills and its management system. This practice corresponded with the most positive safety outcomes in the case study group. This was believed to be a *model for state-of-the-art safety and health management.* This case seems to be similar to and therefore supportive of the model used in the Norwegian offshore industry.

4.2 Safety activities pertaining to the integration model

The following activities are considered a vital part of the integration model

1) General points: Efforts aim at integrating contractors' safety activities into the safety management system of the client firm. The client eases the process by naming a co-ordinator for the integration program. The client provides the contractor with general safety guidelines to be adhered to on-site.
2) Safety course: When the contractor has moved on-site, an important transaction has taken place, and the contractor has to adapt to the new environment. This adaptation is a learning process for the individuals in the contractor's company. The client often starts the relationship with a safety course where the first steps of adaptation to the new working environment are learned.
3) Revision of contractor's IC-systems: If things are in order, the contractor has his own safety documentation pertaining to his activity. This system needs to be adapted to the new working site. This may include not only modifications to the existing system but also addition of new information, for instance, needed to protect the environment and management of emergencies.
4) Reporting of near misses and accidents: Contractors are supposed to report their safety activities. This includes the most important point: to report near misses and accidents.
5) Safety meetings: Contractors shall take part in general safety meetings, held by the client. The safety meeting may deal with problems pertaining to co-ordination and adherence to rules, risk-taking behaviour by contractors, employees, etc.
6) Safety inspections: Contractors are asked to send their safety delegate or other representative to official safety inspections by the authorities, for instance, the Directorate of Labour Inspections.
7) Follow-up actions: Decisions taken in safety meetings lead to follow-up actions. These follow-up actions can be assigned to crew leaders and safety delegates in the contractor's company.

8) Safety campaigns: The follow-up actions have occasionally been transformed into safety campaigns, in which all employees are asked to participate. This practice has been used more frequently in offshore companies to involve all the contractor's employees in continuous safety activities.

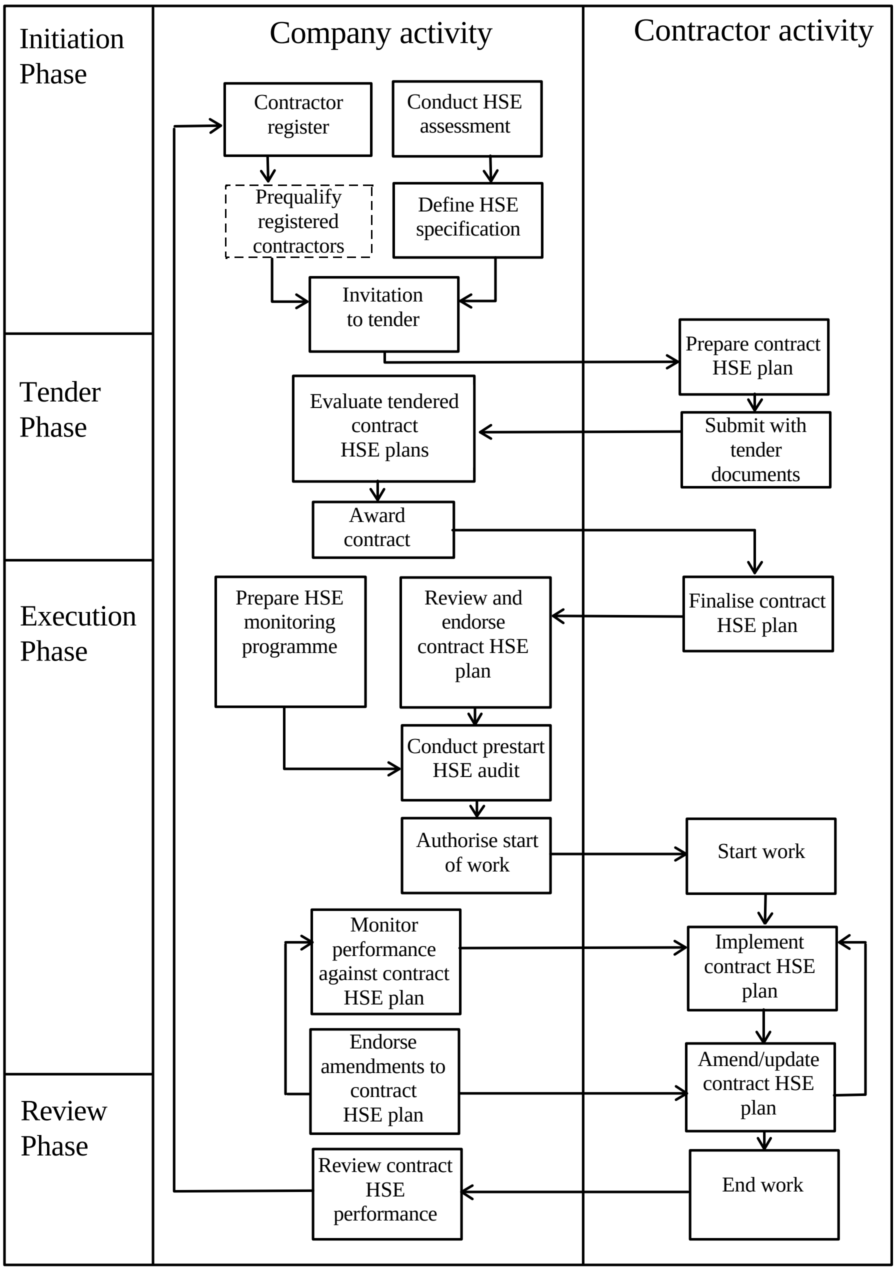

Figure 2 - Main steps in the integration model (adapted from Riyamy and Sartory, 1994)

9) Risk analysis/safe job procedure: Risk analysis with a subsequent writing of safe job procedures is an activity used where potential risks or risks are very high.

10) Accident analysis/statistics: Offshore operators have involved contractors in accident analysis to integrate them in the process. Accident statistics are used to support safety activities and necessary program changes within contractors' companies.

11) Auditing/top-level meetings/new goals: The client uses auditing to check contractors' safety systems. A top-level meeting is called when a contractor's injury rate exceeds average. New goals are set in connection with a top-level meeting. Management commitment is one of the cornerstones in the strategic development of contractors' safety goals.

12) Reward/punishment: The client evaluates contractors on the basis of their safety performance. Their safety record is registered. They may be praised for good performance and get further contracts. If their record is poor, and they have not managed to improve it, they may not get another contract.

Co-operation is needed between contractors and clients. All these measures will not help unless an atmosphere for co-operation is created.

4.3 Case on improving contractor safety in an offshore operation

Phillips Petroleum Company Norway (PPCoN) has been a leader in improving contractor safety in the Norwegian offshore industry. In a paper to the First International Conference on Health, Safety and Environment in Hague in 1991, Lode (1991) presented information on how contractor accident frequency on the Ekofisk platforms was reduced 40% between 1981 and 1984 and further reduced during the period 1989-1991. According to Lode, this progress was attributable to increasing management involvement on behalf of the contractor's umbrella organisation. After a setback in 1987 due to many new employees and, possibly, weaknesses in the PPCoN management system, new programs were initiated. Most of the activities can be found within the integration model. Contractor selection procedures were improved. Contractors were asked to submit a written safety program that was reviewed and modified. Basic safety training was started before going offshore, and there was specific platform training as well. Top-level management meetings were initiated, where safety was discussed in the presence of the contractor's representatives. Goals were set by management for reducing the accident frequency by 50% in three years. Contractors sent a monthly safety activity report to PPCoN, and PPCoN sent out detailed accident statistics to all contractors of a certain size. The management of the contractors' companies was invited to a weekly safety and environmental review committees meeting. Good performance was praised. Poor safety was punished, and contractors with extremely high accident frequencies were asked to improve their status, or they would not have their contract renewed. All contractors with safety records below average were audited. A safety superintendent together with the PPCoN Contract Administrator conducted the audit. For further improvement of contractors' safety, the author suggested that contractors should work more at the lower level of the accident triangle, i.e., registration of near misses, doing job safety analysis, hazard recognition and risk analysis. He stressed quantification of contractor performance and more two-way commitments in contracts, where both client and contractor state their goals and expectations. He stressed environmental performance. In Norway the operator is fully accountable for errors by contractor personnel on installations.

Several other authors on the above mentioned conference could present how new safety programs had lead to a reduction in contractor´s accident rates. Amongst them were Simon and Piquard (1991) from Esso, Blanton and Montgomery(1991) from Shell, Craft (1991) from Texaco. Riyamy and Saratory (1994) from the Petroleum development Oman presented the integration model on a similar conference in 1994.

5. CONTRACTOR INCENTIVES FOR IMPROVING THEIR SAFETY

In the Norwegian offshore industry, contractor responsibilities are specified and classified in a NORSOK (1996) standard on health, safety and environment (HSE) during construction. General compliance with this standard means that practices becomes similar in offshore firms. The standard states that the contractor shall systematically work for HSE in accordance with established principles of quality assurance. The contractor shall ensure management commitment and attention to HSE matters in all phases of the project. The contractor's organisation shall reflect the implementation of HSE matters as a line responsibility at all levels. The standard further states that the contractor, when acting as a principal enterprise, has overall responsibility for ensuring that construction activities are planned, organised, performed and documented in compliance with contractor's HSE program. The contractor is also fully responsible for co-ordinating the HSE activities of each employer (the contractor group and company) working on a contract object.

The foregoing makes clear that a Norwegian contractor is subject to external pressure to ensure that safety practices meet standards. Often, this will improve safety. The internal pressure to improve safety is not less interesting and is traditionally linked to the cost of accidents.

5.1 Cost of accidents

Contractors' loss prevention programs are built into their quality and safety management systems. It seems natural that contractors make every effort possible to avoid accidents and their consequences and use low accident costs as a measure for efficiency in safety performance.

Research, however, indicates (Laufer, 1987a) that the cost of accidents does not seem to play an important role in prevention strategies in construction safety management. The reasons may be many, but one possible reason is that accidents are not related to costs in the planning phase, but are rather considered to be stochastic phenomena or a kind of “bad luck”. The simple accident cost model, the so-called iceberg model, has been used to make management aware of the many hidden costs pertaining to accidents. The model emphasises that most of the costs are very difficult to estimate, but also that many hidden cost items exist and that these costs are much higher than directly visible costs incurred shortly after an accident. A detailed list of the cost items has been made. The following model is derived from Stanford and was made in 1981 (Laufer, 1990).

Direct costs: 1) Insured costs (benefits paid to the victims of the accident).

Indirect costs: 2) Insurance company claims handling and administrative fee, 3) Transportation of injured worker to medical facility, 4) Wages paid to the injured worker for time not worked, 5) Wages paid to other workers for time not worked, 6) Costs of overtime due to the accident, 7) Costs of loss of crew efficiency, 8) Costs due to the breaking-in or teaching of a replacement worker, 9) Extra wage costs to rehabilitate the returning worker at reduced capacity, 10) Costs to clean up, repair or replace damage from accident, 11) Costs to reschedule work, 12) Costs of wages for supervision associated with the accident, 13) Costs for safety and clerical personnel to record and investigate the accident.

This extensive list gives a hint of the problems this approach has caused. Depending on the social security system involved, a third party may pay the biggest part of the costs. The costs are therefore not of equal interest in the cost management of the firm. Second, the time when these cost factors fall due may be very different. It is therefore difficult to perceive the costs as an entity. The many costs that supposedly hit the firm do not seem to be tangible beforehand and can therefore not be included in a management planning strategy in detail since where the accidents will happen is not known. The general policy adopted by many firms is to have some degree of over-manning to meet unforeseen events of this kind. This over-manning is also employed to deal with absences from work due to normal illness like flue and seems a very reasonable strategy. Absences due to illness may in fact be much higher than absences due to accidents. This practice has been observed both in Norway and in the USA.

Accident researchers differ on how important accident costs are to the economy of safety. Laufer (1987a) has published a paper on accident costs and management safety motivation in the construction industries. Laufer did his research in Israel but compared his findings with research evidence from the USA. According to his findings, the average uninsured costs per accident amounted to 100 man-hours or only 0.76% of the total labour costs. In the study, an analysis was made of the methods by which accident costs are studied, collected, analysed and presented. Laufer demonstrated that:

1) the use of the ratio (for instance in the iceberg model) of indirect (or uninsured) to direct (or insured) costs is invalid and should be abolished,
2) uninsured accident costs alone are not high enough to constitute an incentive.

In a later paper on construction safety, economics, information and management involvement, the same author theorises that if this case were widely known, it would bring about change in attitudes, causing management to invest in the tracking of costs and accident frequency (Laufer, 1987b). Laufer assumed that information on accident costs revealed by his research might increase top management's interest in safety.

Rundmo, Söderqvist and Aaltonen (1991) calculated costs of accidents in 57 firms in nordic furniture industries and used new approaches to estimate the real costs. Most cost estimates from the past had used the so-called market pricing model. (This was also done by Laufer.) The results from the study where 460 accidents were analysed showed that costs varied very much depending on the method that was used for the cost calculation. Three models, the accounting model, the market price model and the spare capacity model were used to calculate the costs. The accounting model shows the accounting experiences of the companies that were a part of the study. Only resource costs are evaluated as relevant. If losses of work time do not cause any observable loss of production the firm will not have any costs. The market price model assumes that production time lost by accidents leads to loss of revenue for the company. The model is considered a good estimation when two conditions are met: Firstly that there is no unemployment in the industry and secondly that there is no monopoly pricing on the product market. Rundmo, Aaltonen and Söderqvist introduced the so-called spare capacity model which is used when accidents do not lead to revenue losses but takes account of frequent situation mentioned earlier that companies hire people that step in when ordinary employees are absent due to illness or accidents. This employment means costs in terms of loss prevention. Data on these costs are not available since the amount of redundancy is based on experience or intuitive managerial decisions. The accident costs within this model must therefore be calculated with the data that was available during the research. The results according to these three models were quite different. The so-called accounting model reflected management perception of losses but was not considered to represent the true accident costs. The use of the market pricing model was considered to lead to low estimations of accident costs. The spare capacity model that was developed within the project was tested in Norway and Sweden. Total costs calculated with the model were four times higher than the costs calculated with the market pricing model. The study confirmed the formerly proposed suggestion that the costs are only to a small degree borne by the firm. This was especially true for Sweden and Norway.

A later study carried out by Rundmo and Söderqvist (1994) compared the market pricing model with the spare capacity model. The study object was 39 furniture firms in Norway and Sweden. Altogether 246 accidents were studied and accident costs calculated. Accident costs calculated with the spare capacity model were 2-5 times higher than costs calculated with the market pricing model. The spare capacity model was considered to reflect the true costs of accidents. As before it was verified that a significant part of the costs was borne by other than the firms. These studies were carried out outside the construction industries. Many of the results can be observed as general and can therefore be transferred to the construction industries. New approaches have emerged elsewhere.

In CEC (1993), a new approach in showing how the cost of accidents relates to safety is supported. The most general accident cost model that has been used extensively in safety management is one showing that an optimum for total costs exists if costs of prevention and costs of consequences are kept in range by acceptable degree of safety. This model may be illustrated by Figure 3.

The model actually allows for a certain number of accidents in order to achieve a cost minimum. Basically, it states that the more one puts into prevention the less serious or less costly accidents become. The above mentioned paper recommends that this model be replaced. The new model (Figure 4) seems to fit modern management approaches of proactive safety management better. It plainly implies that after safety activities have been adopted in the contractor's company, the total costs of accidents will decline. Costs of self-motivation may be understood as the costs of the company for safety programs and safety activities that lead to increases in its defensive potential.

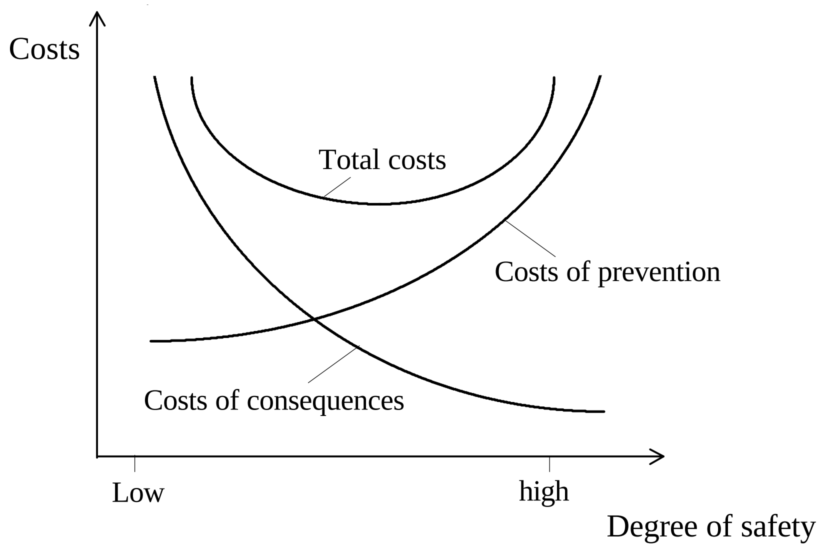

Figure 3 - Total accident costs in relation to degree of safety (older approach) (adapted from CEC, 1993)

5.2 Examples of contractors own cost management systems

Despite the difficulties of using accident costs as a measure of preventive effectiveness, a system of this kind has been used as a control instrument, at least in the USA (Levitt and Samelson, 1987). The purpose of such a system is to estimate accident costs at net present value so that the financial consequences of an accident and possibly, to some degree, the social consequences can be reacted to immediately within a project. The Stanford cost accounting system that was developed by Michael Roger Robinson (1979) uses three variables: (1) part of the body injured, (2) nature of the injury, (3) whether the injury resulted in one or more lost workdays. Several companies in the USA used the Stanford system. Research was done on the use of the system in the companies. The following main conclusions (Levitt and Samelson, 1987) were reached:

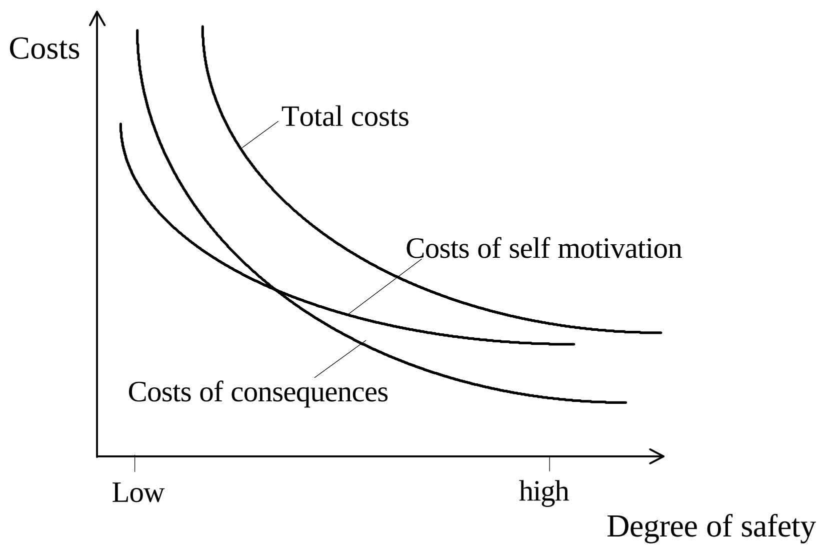

Figure4 - Total accident costs in relation to safety (newer approach) (adapted from CEC, 1993)

1) Costs estimated from the Stanford Schedule are an accurate reflection of insurance claim costs, but are too low to reflect hidden costs.
2) Companies use the system for a variety of comparisons on a weekly, monthly and quarterly basis.
3) The most frequently used single measure developed from the schedule was accidents costs per employee hour worked, which was calculated for foremen, superintendents, projects, divisions, etc.

4) Putting the Stanford Schedule on a computer meant that accident cost records could be kept by supervisor, job, accident type, body part, etc., yet even companies not using computers were able to use the schedule very effectively.
5) Generally, accident cost reports were sent to the president and other top management people and to each project, but some companies also sent them to all supervisors or even to all personnel.
6) Companies using the system felt that it created greater awareness of the cost of accidents.
7) The few evaluators who were able to test the specific impact of the Stanford Accident Cost Accounting System attributed substantial reductions in insurance costs to its adoption.

The system seems to prove that companies who used it showed better risk awareness on all levels in the company, and that they could improve their safety performance. As a result of that insurance companies acknowledged the system as a risk reducing measure and reduced the insurance premiums. The safety performance may in general however be complicated to predict and dependent on many factors that are connected to the way contracting is done in the trade.

6. VIEW ON CONTRACTOR-CLIENT RELATIONSHIPS

The American study mentioned earlier (John Gray Institute, 1991) revealed different safety management practices in its case studies. A wide variability among plants existed in safety and health practices pertaining to the use of contractors. No consensus existed on what constituted best-practice safety management of contractors. This is different in the Norwegian industry as we have observed. Model practices were not diffused to the industry at large. Many activities considered necessary in the safety-conscious firm may not take place in other firms that do not structure their safety in a responsible manner.

Many things therefore differ in the companies, but contracting may include basic activities that may cause similar identifiable reactions amongst contractors or clients. An attempt to elucidate these activities will be made.

Figure 5 shows a limited view of the contractor client relationship during the contractual period as perceived by the author. It shows that contractor and client are linked through formal administrative communication activities that exist as inputs and outputs to the contractor and client system during the most active phase of contracting.

The figure also indicates the not less important exchange of culture and climate through informal communication.

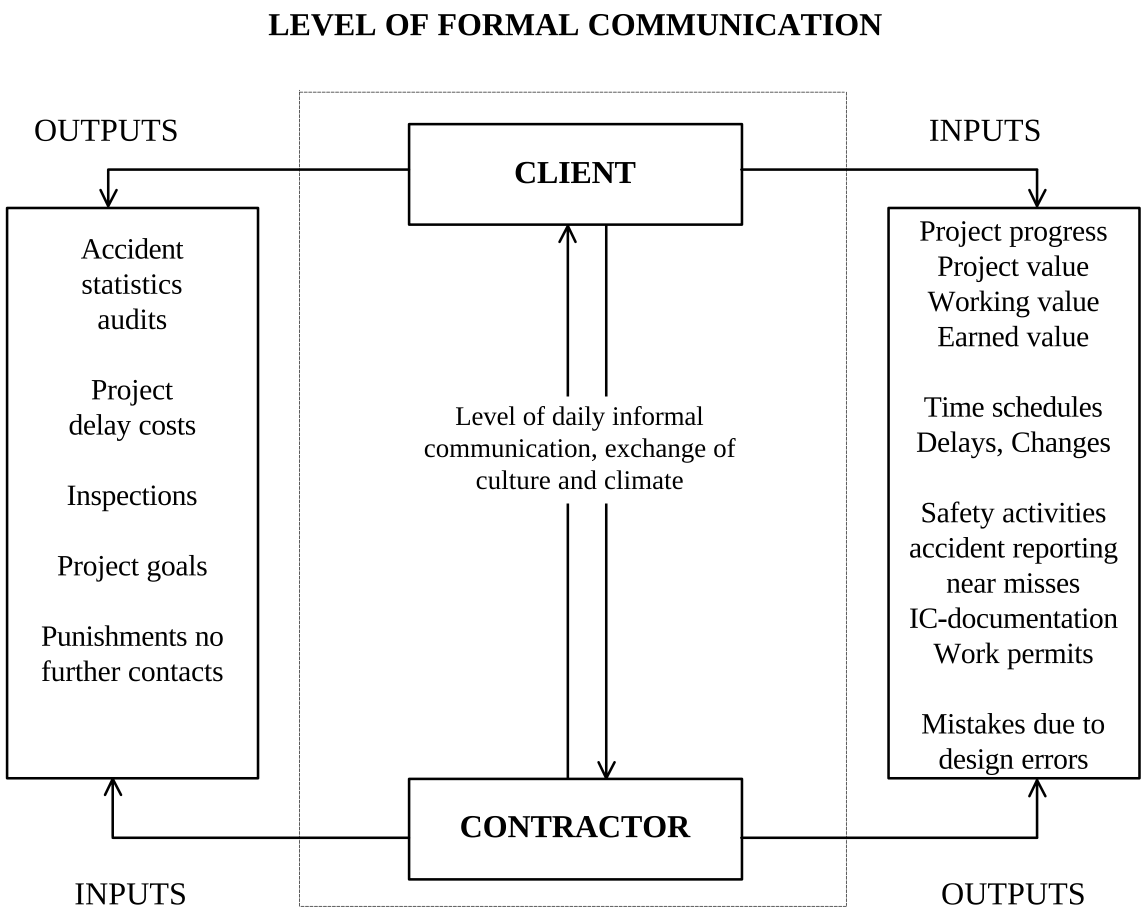

Figure 5 - Contractor client relationship

This view shall indicate that the integration model may not always be functioning It therefore resembles more situation in American industry than Norwegian. The model will be incomplete due to the fact that some functions considered necessary are not carried out in the company involved. For instance the very important labour-management committee seems to function poorly quite often according to the American study mentioned earlier (John Gray Institute, 1991). Contract employee representatives rarely participated in the host's labour-management committee. These groups were rated as effective in improving safety conditions. Contractors reported they were more likely to provide data on their safety programs in plants where committees existed. The study concluded, regarding the usefulness of the meetings: *The more frequently the group met, the lower were the direct-hire lost workday injury rates in the plant.* Such committees were generally found to have a role in giving input for correcting unsafe practices, but not for safety policies. In one case, a "Safe Operations Committee" composed of a "vertical slice" of managers, supervisors, hourly employees and contract employee representatives took on a broader role, including review of training programs and safety and health programs of contract firms in the bidding process. Safety training was associated with lower injury rates for direct-hire workers. The training *seemed to be of less value for contract workers.* This example shows that a blending of contractor and client cultures is most likely good for safety. This beneficial mix or diffusion does not take place under all circumstances.

Generally, however, it is rather evident that the relationship can be strained as well as improved through several formal activities. This is shown schematically in Figure 5. For instance, the contractor has to report mistakes, failures and accidents. Clearly, failures in construction can not easily be hidden in the long run. The temptation may be great not to report accidents that have occurred but have not generally been detected. If strict goals for safety performance are set by the client, an extra reported accident may possibly lower the reference the contractor receives from the client at the end of a project. Strict safety goals by clients may therefore promote non-reporting of accidents by contractors.

It may be concluded that the relationship is complicated and involves a lot of activities that may harm a relationship if they are not brought forward at the right time or in the right manner. For instance, remedying design errors is very costly and becomes costlier the farther a project advances. In the construction phase, an undetected design error may be ten times costlier to repair, compared with an error made and corrected in the design phase. The contractor who has an advanced system for safety activities is much better off than a contractor who does not plan safety beyond a minimum of activities. These activities are documented through internal control documentation (IC-documentation), which is submitted with other tender's documentation in practice. IC-documentation is a description of the contractor's safety management system or safety program. The client knows of it prior to his signing of a contract. The quality of accident reporting and reporting of near misses is a good indicator of the contractor's safety awareness. Reviewing this becomes an important experience for both partners.

Time delays are a worry for most contractors since in many cases they have to pay fines if they cannot follow a pre-planned time schedule. Usually, the client has the power to demand project delay costs if a project is delayed, but he may pay bonuses if a project is ahead of schedule. This is a powerful management tool for the client and accepted practice in the business, but it can create a lot of pressure on contractors' employees and may have negative indirect effects in some cases. The financial control of the project's advances is one of the most important tasks the contractor is faced with. It is self evident that this factor is one of the most important in the relationship. If any changes need to take place, they must be well formulated.

A lot of input comes from the client, and the client has to evaluate his actions carefully. One important aspect is collection of data about injury. Contractor workers' injury data are not being collected by the majority of plant managers according to the American study mentioned earlier (John Gray Institute, 1991) and are therefore not available to OSHA. Neither are accurate data available to the majority of plant managers for the purpose of selecting, monitoring and controlling safety outcomes for contract labour, however, this is important since the client has to follow up on accident statistics and safety by his audits or safety campaigns. Auditing is a delicate task and can become too mechanical or too personal if it is not carried out with proper insight or data. This situation is different in Norwegian offshore industry where auditing has been used more effectively.

The client monitors the project by his inspections. The project goal is visualised in steps as a result of those inspections and other safety activities. The client can make the contractor aware of the fact that he may not get any further contracts if the contractor does not live up to his expectations regarding the quality and safety of the project work.

As stated before contracting may include social problems, and the American study (John Gray Institute, 1991) mentioned earlier reflects on this regarding the human resource profile of contract and direct-hire workforce. Contract workers are younger, less educated, less experienced in industry, lower paid and more likely to be of Hispanic origin. Evaluated on the basis of human capital criteria (i.e., age, experience, education, skill and compensation), the contract labour force is judged to be less qualified than the direct-hire force. This effect will most likely be seen in one form or another in the Western Europe. This has been mentioned indirectly in the presentation of the general problems of the construction industry.

The results from the American study (John Gray Institute, 1991) indicate strongly that it is difficult to build a strong safety culture while contracting. Building of a good safety culture takes a long time and is connected to a long learning process that may not be possible within a short-term contract. The safety climate may suffer especially if accidents happen during a short-term contract. This may be observed as special vulnerability problems within contracting. The human resource problem may be the biggest contributor to high accident rates and possibilities of large-scale accidents. This may also add to the risk pertaining to the situation that funds are limited and contracting is often done speedily under time pressure.

This observation indicates that managers on each side may run risks in the contractor industry. This seems a natural process in this trade and may influence both the project risk and risk of accidents. This is in fact shared between contractor and client. Each of them assumes risk in the common venture of a project. Their behaviour will largely be determined by their willingness to assume risks. This behaviour influences safety climate and culture during the contracting period.

7. WILLINGNESS OF CLIENT AND CONTRACTOR TO ASSUME RISKS

The willingness to assume risks is more decisive for behaviour than the existence of management systems. This has been observed in America where many general contractors took the position that the subcontractor's safety (Levitt and Samelson, 1987) was their own business. This has been a legal dilemma since involvement in subcontractors' safety could mean increased liability. This has changed since 1984, and the absence of involvement is no longer a valid defence against lawsuits by subcontractors against general contractors, construction managers and clients. Accidents to a subcontractor's employees cost general contractors real money, and, for instance, general contractors pay costs associated with delays.

The problem of risk-taking in contracting has many other sides. The American study (John Gray Institute, 1991) mentioned earlier revealed barriers to the diffusion of best model practices amongst the target firms. One can assume that this has to do with attitudes towards risk-taking or running of risks. One significant barrier was the lack of *established consensus* within the industry on what constitutes best practice management as the model or benchmark standard for the safety management of contract workers. The second barrier named was the fear that employers have of *incurring co-employment liabilities*. Primary concerns seem to be the potential financial liability for worker injury and accidents under the pertaining Worker's Compensation law and the possibility of unionisation of contract employees who are supervised directly by the proprietary firm. This policy delegates the responsibility for safety and health to contractors, who often are not as well prepared as the host company to recruit, educate, train and manage their workers in safety and health matters because they are smaller, *have fewer professional resources* and less knowledge of specific workplace conditions and processes. *Labour-management participation* was found to be *not developed* and an obstacle to diffusion of practices that improved problem-solving in safety. The fourth barrier named was *the lack of structure that* promotes learning and the transfer of innovations across organisations and employment relationship in the industry. This was recognised as a bigger problem amongst the smaller sites and smaller contractor firms. Some of the above mentioned problems relate to contracting in Norway as well as in America.

This short overview may serve as a reminder that the question of risks contains many factors since project risks may become merged with other risks during the contract period. The question of whether partners are willing to assume responsibilities for project risks has been dealt with in the literature by Ward et al. (1991), and the following has been summarised as being of importance:

a) General attitude to risk
b) Perception of project risk
c) Ability to bear the consequences of a risk eventuating
d) Ability to manage the associated uncertainty and thereby mitigate the risk
e) Need to obtain work
f) Perception of the risk/return trade-offs of transferring the risk to another party

If we look at the first two points mentioned above, we may understand why it is difficult to bring the subject of detailed risk elaboration into the preliminary stages of a uncertain project. The functioning of contracting in the building and construction industry is based on people's willingness to take risks. Often, a perception of a high project risk would lead to withdrawal from a bid competition.

The contractors are supposed to have four options in bearing the project risks:

a) Pass the risk on to a third party
b) Continue to bear the risk and manage it for profit, but accept liabilities
c) If a downside risk eventuates, try to recover costs from other parties, including the client
d) If a downside risk eventuates, meet liabilities reluctantly, walk away from the contract or go bankrupt

By choosing an inappropriate option, the contractor makes himself vulnerable to outside judgement. This may have an impact on his needed references. The strategies adopted by contractors in managing the general project risk will evidently have impact on the strategies they adopt in HSE-management. If they can pass the risk on to a third party, they may do so. The individual worker or subcontractor may be responsible in case of an accident if the main contractor can show he has initiated some actions and control for a safer working environment.

Project risk management and safety management should ideally be harmonised and merged with each other. But since two or more partners with conflicting financial interests are involved, this will hardly ever happen. The situation is complicated by the role of the social insurance system. The social insurance system may pay benefits to an injured person regardless of the situation leading to an accident and without consideration of blame. The insurance system has different roles when contractor safety is considered. In some countries like Finland and Switzerland the insurance system is monopolistic. In such systems the insurance system may influence contractor safety by lowering premiums in return for good safety records. In other countries the insurance companies have to compete themselves for the market. Their possibilities of improving safety records by strict requirements are more limited. Yet we have learned that cost accounting systems in America helped to reduce insurance costs. Ward et al. (1991) presents prospects for better practices in contracting and risk allocation by the client's use of risk analysis as early as possible in the project. This should be done to reduce risk uncertainty, check the risk-cost balance and determine how risks should be allocated between contractor and client. It should influence the method of payment and form of contract.

A basic problem concerning vulnerability and safety is that bidders are faced with bid submission deadlines that only permit a very incomplete appraisal of the risks involved in the project. The evaluation of the risk exposure and pricing will therefore only be on an ad hoc basis. Ward et al. (1991) points out weaknesses in the present approach, regarding looking at contractors as quasi-insurers and paying them a price for bearing project risks. Ward suggests an approach where all partners accept risks appropriately allocated to them. This should be done by using a formal risk analysis procedure in the spirit of co-operation.

8. DISCUSSION

The paper has highlighted several problem areas related to contractor safety in construction industries in general, as well as to the offshore petroleum production industry. Accident statistics show that construction, as such, is a high-risk industry. If process risks pertaining to the petroleum industry are added, the challenges to risk management will be even tougher. We have found these problems to be different in nature, depending on the country being researched. There are also site-specific problems, e.g., in the offshore industry.

Some of these problems, such as hurried time schedules for work and human resource problems, are deeply rooted in the organisational culture of contracting as it has been developing in the industrial age. These problems seem to exist in all Western industrialised countries with a varying degree of severity. This has not been studied specifically in this paper. The author has suggested that several factors may lead to an increased risk of accidents in the contractor-client relationship. In addition to the problems mentioned above, he points out that contractors often do not have a structured safety management system. Such a system is considered essential and is also compulsory due to law and regulations on internal control. The operators in the Norwegian offshore industry recognised the need to react to this problem, and developed the so-called integration model. Prior to the integration model, clients onshore had also developed related methods. In the USA, these methods were based on the contractor’s past and current safety performance, and the safety performance of the contractor was monitored during the contract period.

Legislators in Norway, on the other hand, looked to the client for solutions to safety problems. A similar approach was developed in Europe. Laws and regulations on internal control were developed, stating that contractors should establish and maintain a structured safety management system. The contractors' safety activities in the Norwegian offshore industry have now been standardised in a NORSOK (1996) standard that outlines how they should carry out their HSE work.

Research from the USA shows that many difficulties are related to structure of the relationship between contractor and client mentioned above. The author has not found similar studies of the client-contractor relationships in Norway and the rest of Europe. He has therefore no basis for claiming that the situation is better in these countries than in the USA.

But is it possible to do better generally? There is reason to believe that the communication of risk between contractor and client is essential. Safety meetings have to include the right people from contractors and clients, and they have to deal with relevant subjects. The same applies to follow-up meetings. Clients have included contractors in accident analyses. It is a very difficult subject, and it may not necessarily help to include contractors in these analyses unless they are willing to bear the burden of blame. Similarly, incidents have to be dealt with objectively. They may otherwise not be reported or even not be dealt with by the client if they seem to be too many or too costly. This seems to have been done at PPCoN in the Ekofisk field in the North Sea. The most evident breakthrough in contractor safety performance seems to have taken place at PPCoN. The company claimed that it could do even better if the contractors would work more efficiently at the lower half of the accident triangle – doing hazard recognition, job safety analysis and risk analysis. Contractors usually claim that it is difficult for them to have their employees do these tasks. Expertise to carry out such work will usually be available only in the larger contractor companies. PPCoN further claimed that two-way commitments should be stated where both client and contractor would state their goals and expectations. In addition, the company stressed the importance of environmental performance. This makes sense. The goals for expected safety performance become more realistic this way. High environmental performance is important and may be linked to positive safety culture or climate. Good safety climate means respect for safety and therefore contributes to an improved safety performance.

9. CONCLUSIONS

It is evident that hurried time schedules, working in new environments and moving to new places, organisational culture and hard competition on the contracting market make the contractors more vulnerable to disruptions or accidents than other companies that have permanent sites and stable working conditions.

The problems on a big construction site may be complicated by a large number of contractors and specific risks pertaining to activities on the site like drilling for oil or building high structures. The co-ordination of the contractors' activities must be smooth and effective. At the same time, effective control of contractors' safety performance is a difficult and challenging task for the operator or the client.

High accident rates amongst contractors in offshore industry in the 1980s have improved considerably in the 1990s. The improvement may be attributed mainly to an increased focus on various safety activities. A better risk communication between clients and contractors is an important factor that has contributed to the improvement. The HSE work in the offshore industry has become standardised, thereby defining the duties of contractors clearly. This trend is expected to continue in the future.

The cost of accidents is not considered to be so much a decisive factor as an incentive for contractors to improve efforts in safety. The estimates used in accident cost calculations differ significantly, depending on the model applied. Many contractors operate with low profit margins, and project risks may be big in relation to expected losses due to accidents.

Cost information systems have been successfully developed in the USA. Insurance companies acknowledged the system as a risk reducing measure and reduced the premium if contractor companies had such systems.

Legislation has improved in that it has clarified the duties of each partner within the construction process. This may be expected to improve even further in the future by taking into consideration more problems in this field.

We have observed that management by objectives has been used to improve the safety performance with good results. We have stated that goals should not be set too high. It has been pointed out that two-way commitment to goals and expectations was beneficial. Otherwise, non-reporting in one form or another may result.

The integration model seems to be the best available method that is known today for controlling contractor safety. This is supported by research, based on real experience from many companies.

Problems within the US contracting industry seem to be more complex than the problems within the Norwegian industry. Characteristic are the human resource problems, the tendency to employ underpaid labour that is not unionised and the dispute about what should be recognised as the best available safety practice. The social problems in Europe may, in some countries, be similar to those in the USA. There are, e.g., rumours about underpaid labour from Eastern Europe being used in the construction industry in the wealthy countries in North-western Europe. This rumour calls for further research.

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