Risk Management: Role of Societal Factors in Major Industrial Accidents

Jan Hovden and Marvin Rausand
Norwegian Institute of Technology
N–7034 Trondheim, Norway

Gleb Sergeev
System Research Institute
Russian Academy of Sciences

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Abstract

The paper discusses factors influencing the occurrence of major accidents in complex technological systems. Societal factors are identified as most significant in this context. Important types of societal factors are pinpointed and discussed. The safety situation in the former Soviet Union and in today's Russia is described. The calamities at Chernobyl, Three Mile Island, and partly also Bhopal are discussed, and the role of societal factors identified. A main point of view is that it is not surprising that these catastrophes happened in the then existing conditions. What is surprising is that they did not happen earlier!

Introduction

A great number of publications devoted to various aspects of industrial safety and prevention of accidents are available, covering a wide range of different fundamental and applied issues. A distinct and significant tendency may be noticed in this literature; the emphasis is usually put on the immediate and direct causes of serious industrial accidents, i.e. on technological, managerial and operating failures, faulty decisions and actions of personnel, defective designs or constructions, etc. This emphasis is understandable and cannot raise, of course, any objections.

Industrial accidents do, however, not arise in isolation from societal factors. A variety of social factors are strongly affecting the level of safety, and are necessary for industrial systems to function effectively and economically. Changes in the society, especially the introduction of various regulatory mechanisms, and the need to employ educated, qualified personnel with specific abilities for positions of responsibility on hazardous industrial installations are adding new, societal dimensions to safety, transforming it into a multiaspect problem.

Research and numerous accident inquiries show that in an overwhelming majority of cases serious industrial accidents must have other, more concealed and deep–rooted causes than direct engineering and managerial faults, however serious they might be. Regrettably, *indirect* causes of major accidents, that appear to be not connected with safety per se, often remain unidentified. Among them *societal* factors (in the broadest sense of the term) should be named in the first place, as they often play a specific and essential – though not always easily discernable – role in serious industrial accidents.

Powerful factors of social character *in conjunction* with other factors create *preconditions* for any serious industrial accident. In a certain sense all these factors; technological, managerial and societal, acting simultaneously and together, make these accidents in a sense inevitable (not, however, at a definite place or time).

From this point of view serious industrial accidents emerge as complicated socio–technological phenomena characterized by not only the level of technological development and engineering foresight, but also by the specifics of socio–political systems of a particular country, its societal management arrangements and institutional structures, behavior motivations of personnel participating in industrial activities or in some cases of the population living near industrial plants. It seems important to detect all these factors predetermining the accidents before (however strange it could sound) they would happen in reality. These factors are not unique or specific of any country or region. The Chernobyl, Three Mile Island and Bhopal accidents, and in fact any other catastrophes of such a magnitude could happen in any country with a developed industrial base. Thorough analysis of major accidents should – and in many cases does – reveal the interplay

of these factors, societal including, and their impact on the general state of safety.

Political, economic, environmental, and also socio–psychological dimensions, social mentality and motivations of various groups of people, even individuals, directly connected with industrial processes per se should be included in the range of these factors.

All this, certainly, does not mean that these factors are fully ignored by analysts, investigators or scientists. Sufficiently wide research has been made to that effect, but to a conspicuous degree it is concentrated on social aspects of the "consequences", that is social impacts of the accidents, what happened *after* them. It seems much more important to detect these factors and take them into consideration *before* they could produce an emergency situation or result in an actual disaster. Analyses of serious industrial accidents should reveal also the deficiences in socio–economic systems, societal mechanisms and methods of social organization and management which in the long run may become instrumental in creating "favourable" conditions for man–made technological accidents.

The experience accumulated so far and the specifics of serious industrial accidents compell to look at the phenomena from a broader point of view, owing to at least two reasons:

(i) In complex technological systems of strictly balanced design, in particular hazardous by the nature of their processes, failures often produce intricate chains of events, leading to unpredictable coincidences of equipment failures, managerial faults or operators' mistakes, defective designs or socio–psycological problems ("human factors") with serious accidents as the end result. The whole array of all these causes might be easily overlooked, as many important data or information could be irrevocably lost in the course of accidents, ignored or even intentionally hidden.

(ii) It is usually meaningless to look for a single *main* cause of a major accident, though for practical, for instance legal purposes, a principal cause is often chosen and accordingly declared.

Our main point is: *societal* factors should be included in the number of probable causes of serious industrial accidents, and their role in making accidents realized or probable defined. This should be understood in the sense that powerful factors of the social dimension, in conjunction with other factors, create general *preconditions* for industrial calamities.

The role of societal factors is especially evident in countries where radical societal changes and upheavals are taking place. This aspect is especially important. The development of appropriate safeguards against accidents should take into account changes and perturbations in the political and economic spheres, and their possible effects on the safety situation in the industrial sector.

Rapidly changing socio–economic conditions in these countries are finding their particular expression in the redistribution of incomes and welfare benefits, of the ownership of large industrial plants, growing economic problems and inflation, rapidly changing political climate, etc., and are usually resulting in new relations in the industrial sphere, and patterns of motivations and behavior of people engaged in industrial activities. Profit considerations, for instance, may produce particularly negative and long–lasting impacts, as entrepreneurs in a rapidly changing economic climate try to ensure extra profits in shortest time, economizing on every possible measure, including safety.

The safety situation in Russia

The Soviet Union with its highly centralized, deeply planned, and administratively run socio–economic system had for a long time been suffering serious losses connected with industrial accidents. All the factors mentioned above were acting together and resulted in heavy material and social losses for the Soviet economy. According to several research projects undertaken in Moscow and Kiev, aggregate losses due to industrial failures (excluding the Chernobyl catastrophe) amounted in the 1980s to approximately 15–20 billion roubles per year (in 1986 prices), which roughly corresponded to 20% of the appropriate global losses! The consequences of the Chernobyl catastrophe alone were for the country shattering, but in fact have never been properly and reliably estimated. Different figures have been mentioned, starting with the official 8–11 billion roubles, reaching 200 to 300 billion roubles (in 1986–88 prices) or more, appearing periodically in the press. Nowadays the problem of the assessment has evidently been dropped altogether probably because of the absence of suitable methods to apply to this case and inability to arrive at a realistic and reliable conclusion.

The analyses of developments in the safety sphere in the former Soviet Union and later in the Russian Federation, its prime successor, deserve special attention, as they present both an illustative and instructive picture of the developments in the safety sphere of considerable scientific and applied significance.

The safety situation in the USSR was mainly the result of inability to introduce appropriate and long overdue improvements in the regulatory and other safety mechanisms so that they could correspond to the requirements of the highly developed industry the USSR possessed. For such a situation to emerge there were several important reasons which were specific for the then existing socio–economic conditions in the country:

- The most obvious reason was that the industrial safety problem in the USSR remained practically outside the immediate attention and interest of wide scientific and professional communities until the mid 1980s. Though some scientists of position expressed serious concerns in connection with the safety situation, especially in the nuclear industries, the general pattern had not been changing, lack of any effective research continued, administrative measures were practically non–significant on national level.

- Serious harm had been inflicted by the so–called *"absolute safety"* concept, based on the general premise that protective measures of exclusively technological and managerial character were sufficient to ensure complete safety ("absolute" in their parlance) of complex techno–industrial systems.

- Central industrial ministries had at their disposal considerable economic, administrative and other means to compensate for the losses connected with accidents on subordinate plants, so practically nobody was much interested in gathering and analyzing, more so in disclosing real data about accidents.

- Concentration of all essential data and information concerning industrial accidents in central administrative bodies, especially dealing with nuclear, aerospace or military activities, almost inevitably resulted in the concealment of all data on security grounds with negative effects on the resolution of safety problem on a national level. Absence of aggregate statistical data aggravated the safety situation during that period.

- A rigid system of strict *secrecy*, permeating the USSR industries (military and non–military alike), resulted in artificial barriers for the exchange of safety information and the accumulated experience not only between different branches but even plants. Eventually it became a serious obstacle to technological progress in general, and to safety particular. The corollary was the neglect of *world experience* connected with industrial accidents. This aspect had extremely negative effect on the nuclear industry. The TMI accident data, for instance, that was widely known in the West, got a limited circulation in the Soviet nuclear establishment. The information was generally unavailable to rank–and–file engineers and operators, and other professional groups that should have got direct access to the data. This information might have prevented the numerous cases of blatant disregard of operational instructions and carelessness of operators.

With the beginning of "glasnost" in the 1970s many serious drawbacks in the safety sphere began to appear in scientific publications and mass media. Information about accidents, available earlier only to a narrow circle of high administrators, could now be analyzed by specialists not connected with the administrative apparatus.

The Chernobyl catastrophe demonstrated to all the seriousness of the safety problem and the necessity of radical changes to counter negative tendencies.

In Russia (after the dissolution of the USSR) the safety developments have taken place in different socio–economic and political conditions with different societal forces and basic motivations. Several specific features and data may be singled out (referring mainly to the period 1991–93):

- *Growth* of the number of accidents in the industries and of traumatism projected even on the decreasing industrial activity during that period;
  (In 1992 the number of fatalities in the industrial sector of economy increased by 17.2% compared to 1991. Transportation of hazardous materials led to 12 serious railway accidents with heavy loss of lives, and a large number of less significant incidents, including more than 800 releases of dangerous or toxic materials. In the mining industry more than 68% of the losses were connected with accidents. Traumatism in open mines increased by 83% In the building materials industry – 2 times).

- *High accident rates* in the industries had been directly connected with negative social developments in the industries. Lowering the level of technological and general discipline on the plants became common and chronic, often connected with such social evils as abuse of alcohol.

- The use of *obsolete* equipment in Russia and the former USSR republics.

(Half of the park of industrial elevators has already far exceeded their maximum lifetime. Replacement of more than 2 000 kms of gas pipelines could not be delayed any more, 10 000 kms require urgent anticorrosion protection measures. A grave situation with gas lines exists in large cities. In the oil and gas processing industries, a significant part of the installations inspected during the last years should be immediately decommissioned or urgently reconstructed).

- The *break* of traditional ties between various branches of economies of the former USSR republics and between plants has resulted in interrupted spare parts deliveries, disrupting maintenance and repair activities and impairing safety stability of the plants.
- In the Soviet Union the legal basis for safety regulation had been essentially the result of administrative activity creating a system of *by-laws* issued by appropriate governmental agencies. The legislative practice in the form of national safety laws in fact was insignificant (mainly concerning standardization). The situation had become a main obstacle to effective accident prevention on a national scale. Incidentally, general safety legislation still has to be created simultaneously with structural changes in Russian economy, a difficult and time-consuming task.

If these and other negative trends are not controlled, the future developments might be troublesome, indeed, with a highly probable further growth of accidents, increasing traumatism and environmental impacts. Naturally, more and more attention is being paid in Russia to change the existing safety situation. Recently there have been some important governmental decisions, relating to state regulatory mechanisms and the organization of fundamental and applied safety research (e.g. the "Safety" state program for 1991-95 or similar state programs for environmental protection and other activities).

A *comparative analysis* of actual major accidents is most appropriate here, relying mainly on the conclusions of various investigative bodies and omitting technological and operational aspects.

The Chernobyl Catastrophy
(April 26, 1986)

From a purely technological point of view the Chernobyl accident did not add anything significantly new to the existing knowledge. The accident, however, became a tragic lesson for the country, the results of which, may not have been fully comprehended up to now. Just as an illustration: now, 9 years after the Chernobyl catastrophe, Russian nuclear industry still does not have a developed legislative support for its activity!

The Chernobyl calamity was unique in several other aspects - large masses of population were exposed to considerable radioactive fallout; biological, socio-psychological and ecological effects spread over large territories with repercussions on a continental, if not global level. It happened during a period of general social complacency and was completely unexpected for all - governmental officials, managers, scientists and specialists, not to mention the public at large.

The existing evidence supports a conclusion that it was a clear case of operators' conformism, inability to think independently and make *competent* assessment of the situation with appropriate personal behavior. It was also the expression of technologic illiteracy on the part of managers and the irresponsibility on the part of supervising agencies accustomed to the breach of duties.

An important factor on which the accident shed light was the system of personnel selection. Of course, there is not much guidance on "correct" selection methods, due mainly to the difficulty of defining criteria for successful managers' or operators' performances. But *deficient* systems of personnel choice for responsible managing and operating positions should be emphasized. People with insufficient technical knowledge, work experience or inappropriate personal qualities were appointed to the positions of exceptional importance. The manager and chief engineer of the Chernobyl plant, for instance, appointed according to the then existing procedures, were not nuclear specialists and had no appropriate education. Not surprisingly, they possessed only vague perceptions of the processes in the reactors, which eventually led to the tragic results.

So, this unprecedented man-made calamity was only in part a technologic failure, in its essence it was a case of a gross social failure.

An opinion exists - it is not surprising that the Chernobyl catastrophe happened in the then existing conditions. What is surprising is that it had not happened earlier!

One of the main results of the Chernobyl accident is that the problems of the Russian nuclear industry since then have become almost exclusively of societal character.

The Three Mile Island Accident (March 28, 1978)

The law suits and the investigations of the TMI-accident disclosed, according to Perrow (1984), a seemingly endless story of incompetence, dishonesty and cover-ups both before, during, and after the accident.

The work of the Kemeny commission acquired a particular significance, revealing the irresponsibility of the utility company (Metropolitan Edison) that had not been managing the nuclear installation properly. There were also cases of cheating on the part of the appropriate company's officials before the accident, and attempts to cover the real safety situation on the plant. It is remarkable that during the qualification tests readministered after the accident, one-third of the licensed operators failed to pass them. The most damaging of all was, however, the fact that inadequate, improper and even criminally punishable procedures had been used for certain leak-rate tests at the TMI unit-2 *prior* to the accident.

The Kemeny Commission noted: "The major factor that turned this incident into a serious one was inappropriate operators' actions, to which many factors contributed, such as deficiencies in their training, lack of clarity in the operating procedures, failure of organizations to learn proper lessons from previous incidents, and deficiencies in the design of the control room .... We are convinced that an accident like Three Mile Island was eventually inevitable".

In the final conclusion the Commission stated that it was the case of cataclysmic human errors that eventually led to the accident.

Again a serious societal failure in conjunction with technological and managerial ones.

Almost the same basic conclusions could be drawn from the analysis of the Bhopal tragedy which, certainly, had specific societal and managerial features as the general conditions were different, in particular the owner of the plant was US-based Union Carbide, a transnational company, running the plant from the United States with the socially complicated situation in India.

Conclusions

A number of other social factors of significance can be named which could play an important role in safety issues, such as economic factors, general political or economic stability (or rather instability) in a region or a country or the professional or general education level of the workforce, which all affect the motivation or the behavior of people in the course of industrial activity, their attitude to their functions and to safety requirements.

A wide range of effective societal instruments is now at the disposal of specialists, which could considerably increase the industrial and environmental safety, if applied effectively and diligently. Among the measures of this kind are:

- Development of effective regulatory and legal bases for safe and effective operation of complex techno-industrial systems. World experience has proved that the existence of developed safety regulatory mechanisms is one of the prime prerequisites for effective prevention of industrial accidents.
- Effective participation of the public in the resolution of safety issues, in particular connected with the construction of hazardous industrial installations in areas where the public interests or rights could be affected.
- Wide use of methodologies developed by national and international research institutions with the purpose to raise general safety level of the technologic processes and the security of the population and the environment; the creation of the international specialized data banks on accidents and preventive measures.
- Growing importance of international activity in the prevention of serious industrial accidents, minimization and localization of harmful conseuences should also be stressed. Interconnections and interactions between nations in the safety sphere are now acquiring such a focus that the formalization and internationalization of safety regulation procedures and standards, and elements of compulsory enforcement of certain agreed actions is now on the agenda of diplomatic activity.
- Construction of industrial systems which could correct wrong decisions or actions of personnel, in particular systems with intrinsic safety features (e.g. nuclear reactors);
- Introduction – wherever possible – of licencing mechanisms with participation of the public and open hearings for hazardous industrial installations and independent administrative control of their performances;
- Introduction of the system of "proofs" to provide evidences that a candidate for a particular

responsible position on an industrial installation with high risk of accident or hazards possess necessary abilities and qualification to be accepted. The lists of such positions should be adopted by appropriate legislative acts.

The pace of technologic change and growing scale of industrial activities is now so great that to rely on conventional evolutionary "trial and error" approach to achieve optimal decisions becomes unproductive. Now it is necessary to forsee the problems which could arise in the course of operation of a plant or a process in order to overcome them in time.

The Chernobyl and other major industrial accidents have provided a convincing answer to the question why an emphasis should be made on societal dimensions of safety in complex technological systems. Only well organized and effectively run ("sustainable") societies, where developed administrative, legal and public mechanisms provide solid basis for the decisions and activities in the safety sphere, could cope with catastrophic and hardly predictable man–made and natural calamities in a most effective and sparing way.

The safety problem could be successfully (taking into account its relative character) solved only if all the safety aspects, *societal* including, are considered in their entirety, as a *system* of realistic measures and actions viewed in perspective and serving a common purpose – to prevent nontrivial industrial accidents or to essentially limit their destructive socio–economic and environmental consequences.

So, the points submitted here seem to give sufficient ground to assert that at the present stage of industrial development it is not so much the techno–engineering aspects that assure safe operation of complex industrial systems, it is their societal components which in the long run might decide the success of the industrial safety efforts.

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