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OUTLINE SAFETY DOCUMENT FOR MAJOR ACCIDENT HAZARDS IN HUNGARY

Final Report

by

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AEA TECHNOLOGY

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AEA TECHNOLOGY

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SUMMARY:-

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EXECUTIVE SUMMARY

The countries of Central and Eastern Europe have undergone fundamental changes in recent years. Economic and institutional development in particular are key elements in the drive towards democratic market economies. However past legacies present an enormous barrier to be overcome. In the field of safety and the environment the performance of these countries has been poor in comparison with Western standards. The depth of the problem is so acute that potential investors are looking elsewhere. This, in turn, is restricting these countries' economic development.

The desire to join the EC will also be hampered if regulatory and legislative systems prove inadequate.

The area of major hazards, in particular has received little attention in Central and Eastern Europe. In the EC, following a number of serous accidents, the Seveso Directive was introduced which obliges member countries to set up and manage a regulatory system for the control of major technological hazards. Risk assessment has been adopted by most member countries of the EC as an appropriate methodology for assessing major hazards in response to the Seveso Directive. The actual application, though, has tended to vary across a spectrum ranging from qualitative to highly quantitative in nature.

This report describes work for UNIDO in developing an appropriate risk assessment methodology for Hungary to assess safety and environment related risks from hazardous industrial operations. The methodology is intended to satisfy the requirements of the Seveso Directive for a safety report to be submitted by the operators of hazardous plant to the regulators.

The three major components of the project were:

- the provision of a risk assessment methodology consistent with the Seveso Directive - the main beneficiary of this being SAFEORG, a Hungarian technical safety organisation sponsored by several major industrial companies;

- the execution of a safety assessment of a chlorine production and storage plant which had been chosen for a trial assessment - the main beneficiary to be BVM, the operators of the plant, particularly in respect of the report's recommendations for improving safety; and

- the provision of advice and recommendations on setting up a regulatory system for major hazards - the main beneficiary being the Ministry of Industry and Trade.

During the course of the project these expectations were covered by the development of a methodology which was used in a pilot study of BVM's plant. A presentation was also given to the Ministry by an Inspector of the UK Health and Safety Executive who was part of the project team on the UK experience of setting up a regulatory system for major hazards.

The risk assessment approach consists of the identification of major hazards and their evaluation in terms of likelihood of occurrence and estimated consequences. Subtle but important differences in risk assessment approaches are discussed. A risk assessment is of little value to government or industry on its own. The value of the approach is in providing a framework on which to base action plans and investment decisions to improve safety and environmental performance, as well as to provide comparisons with other plants for regulatory purposes.

The information requirements for the methodology are:

- information about the process;
- information about the way it is managed;
- information about the its hazards.

The information is developed using series of forms (and guidance notes) which are compiled into an Outline Safety Document (OSD). The OSD is compliant with the safety notification required under the Seveso Directive.

The importance of the management information is that a well run plant which places good safety performance as a major objective will tend to pose lower risks to the workers and general public. Hardware and engineered improvements can also have a significant effect in reducing risk levels. However, the lack of resources in Central and Eastern Europe emphasises the importance of cost-effective options for better safety performance. Improvements in safety management procedures and practices can therefore be the preferred means for raising safety and environmental standards in these industries.

The feasibility of the methodology was tested on the chlorine production and storage plant in Budapest during a week long visit in January 1993 under the auspices of SAFEORG. The pilot study involved the cooperation of plant managers and operational staff and assistance of two technical consultants, primarily for translation services. The general levels of support, assistance and hospitality received were more than we could have expected and made a significant contribution to the success of the project.

Our assessment of the methodology suggests it is a straightforward and relevant approach for Hungary, in the current circumstances, able to identify practical solutions and provide compliance with the Seveso Directive. With this in mind we have made a number of suggestions for further assistance to Hungary would be beneficial, focusing on transfer of the relevant technology.

Furthermore, with the level of commitment and backing we have found during the project it is possible that a major programme to support the development of a safety culture in Hungary could lead to significant societal and economic benefits for the country.

CONTENTS

ANNEX 1: GUIDANCE NOTES

ANNEX 2: DATA ENTRY FORMS

ANNEX 3: ASSESSMENT OF PRODUCTION, STORAGE AND SHIPMENT OF CHLORINE AT BVM, BUDAPEST

Although this project makes use of guidance issued by the Health and Safety Executive (HSE) and involves an HSE Inspector as part of the project team, there is no implication that HSE approves either the methods developed under the project or the views expressed in this report. The methods and views are the responsibility of SRD.

1 INTRODUCTION AND BACKGROUND

1.1 UNIDO Request for Proposal

In October 1992 the United Nations Industrial Development Organisation (UNIDO) issued a request for proposals to develop a methodology for quantitative safety and ecological risk assessment for hazardous industrial operations in Hungary. From the request it was apparent that three factors are driving the Hungarian Government and industry to review the national approach to managing safety and environmental issues arising from the operation of heavy industrial plant.

- There have been a number of serious accidents involving environmental damage and injuries to workers.
- There is a requirement to assure potential private investors in Hungarian industrial concerns that their investment will not be compromised by poor safety or environmental performance.
- In order for Hungary to join the European Community (EC) it will be necessary to have a regulatory regime which is consistent with the framework of directives set up by the European Commission.

In these circumstances it was perceived that an appropriate response would be to introduce quantified risk assessment (QRA) methods into Hungary with a view to reducing the risk of accidents, providing confidence to potential investors and moving toward a regulatory regime which was in conformance with EC legislation.

The Environmental Management and Industrial Safety Division of the Hungarian Ministry for Industry and Trade, represented by the industrial safety association SAFEORG, therefore approached UNIDO for support in taking this forward. UNIDO's request for proposals sought projects which would "enhance the capabilities of MIT and SAFEORG to introduce and apply an EC-conforming methodology of quantitative assessment of ecological and labour-safety risks of industrial operations" in Hungary.

As pioneers in the development of QRA techniques in the nuclear, chemical and offshore industries, SRD was pleased to respond to this request and was granted the contract.

1.2 Structure of the Report

This is the final report on the project which is required under the terms of the contract.

The report is structured in the following way. Section 2 sets out our initial approach, both to the development of a suitable methodology and to the other activities involved in the project, each of which is expanded in the subsequent sections. Thus Section 3 deals with the methodology, Section 4 with its trial application and Section 5 with some discussions held with the Hungarian regulators. Section 6 draws together the conclusions and makes recommendations for future work.

As well as the main report there are a number of Annexes. Annexes 1 and 2 contain the guidance notes and data entry forms developed for the methodology - essentially these comprise the methodology itself. Annex 3 contains the results of the application of the draft methodology to the production, storage and shipment of chlorine at BVM in Budapest. This is essentially a safety assessment of the activity which is intended to be of use to plant management in bringing about safety improvements at the plant and demonstrates the feasibility of the methodology.

2 INITIAL WORK

2.1 SRD Technical Approach

In answering UNIDO's request SRD wished to set a direction which provided maximum value in terms of increased industrial and environmental safety in Hungary within the constraints of the budget. We also wished to set QRA in a context which was consistent with EC directives. There are two major factors which need to be considered in doing this.

- The main directive relating to major industrial hazards is 82/501/EEC, the Seveso Directive. This sets out a number of measures which Member States must take to prevent major accidents and limit their consequences for man and the environment. One of these is to set up a competent authority (or regulator) and another is a requirement for manufacturers to provide a notification of certain industrial activities to the competent authority. This notification is often known as a safety report or safety case. A third is a requirement to notify accidents if they occur.

- There is no requirement within the EC for risk assessment (that is, an assessment including some form of estimate of the *likelihood* of an event), still less quantified risk assessment, to be carried out. The Seveso Directive is one of several which requires some assessment of hazards, but it does not require any assessment of the likelihood of these hazards arising. This is because the concept that accidents may still happen when all preventative measures have been taken is not one that is acceptable within the legislative framework of all EC countries. Therefore the approach to implementing Seveso has varied in the different countries, ranging from requirements for full QRA to assessing only the consequences of potential accidents.

To put this in context it is worth discussing in more detail the roles of *risk management*, *risk assessment* and *quantified risk assessment*. Managing risks involves five basic tasks:

- identify the hazards - what can go wrong;

- estimate the likelihood of occurrence - how often it will go wrong;

- estimate the consequences - how bad it is if it does go wrong;

- evaluate the hazards in the light of: their likelihood and consequences; the alternatives for risk reduction; legislation; and the guidance of regulatory authorities and others; and finally

- decide what to do.

The first four steps are known as risk assessment. If the estimates of likelihood and consequence are developed numerically - the likelihood may be expressed in terms of the probability per year of the accident happening, for example, and the consequence may be expressed as the number of people killed - then the process is quantified risk assessment (QRA).

But there is a clear distinction between risk assessment and QRA. This results from the fact that crude estimates of likelihood and consequence may be adequate to provide the appropriate level of control of hazards. What is more important is to identify the hazards as systematically and completely as possible, and to demonstrate that there are provisions for their control in place. As an example, the Management of Safety at Work Regulations which came into force in the UK on 1 January 1993 require all employers to make risk assessments for their workforce and for people affected by their undertakings. As can be imagined, it is not anticipated that these assessments would be quantified in most cases, simply that the hazards are identified and the extent of the risks evaluated.

A similar approach has been taken in the UK in its response to the Seveso Directive - the Control of Industrial Major Accident Hazards (CIMAH) Regulations. This requires the submission of a safety report in certain circumstances, and one of the objectives of the safety report is, "to identify the type, relative likelihood and consequences of major accidents which might occur," but there is no requirement for QRA. This can be contrasted to the approach in other EC countries such as the Netherlands where QRA is a requirement or Germany where no account is taken of likelihood.

Another contrast in the EC concerns the nature of the regulatory approach. In some countries a prescriptive approach is taken which forces manufacturers to conform to certain standards and procedures, and provided the manufacturer has taken these measures he is not obliged to consider safety further. In other countries, including the UK, a "goal-setting" approach is used. This means that manufacturers have both to set out their intentions for achieving safety and to demonstrate how these have been met. Both aspects are then discussed with the regulator. A risk assessment provides a good framework for presenting the manufacturer's position, and subsequent discussions.

Thus the competent authority in the UK, the Health and Safety Executive (HSE), operates a goal-setting regime in which risk assessments required under the various regulations play a major role. Such a regime encourages a pro-active approach to safety by manufacturers. This means they must analyse their safety problems and devise appropriate policies and safety measures rather than simply respond to accidents and prescriptive legislation. The approach attempts to provide the most cost effective approaches to safety, based on making risks as low as reasonably practicable (ALARP). It also aims to reduce cases of expensive but ineffective safety provisions which can arise under prescriptive regimes.

Another aspect of this approach is the role played by safety management. It is increasingly recognised that quantified risk assessments are based on averaged data which take no account, in particular, of the quality of the management of the plant. However, it is known that the quality of safety management has a major impact on risk: numerous recent disasters show that accidents happen when the management systems have broken down or are ineffective. Thus in assessing the safety of a plant it is important to assess the safety management systems to develop a view of their impact on risk. It is expected that this will be a feature of future amendments to the Seveso Directive.

SRD has worked with the HSE for many years while the concepts outlined above were being developed and we felt that the UK approach, suitably modified, would be appropriate for Hungary.

Thus our proposal was framed around providing a methodology for a safety report which would both be compliant with the notification requirements of the Seveso Directive and exploit the benefits of the risk assessment approach. This safety report was to be termed the Outline Safety Document (OSD) and would focus on the identification of hazards and assessments of their likelihood and consequences, but not the quantitative aspects of these. This would have the benefits of:

- providing a methodology for safety notifications which would be compliant (or nearly so) with the Seveso Directive and anticipated changes;
- focusing on the major benefits to be obtained from a risk assessment approach without getting immersed in the details of the quantitative aspects; and as a result
- providing a cost effective way of assessing the safety of as broad a range of plants as possible within limited resources.

This methodology could then be used in a number of ways. However we proposed that initially it should be implemented as a joint exercise between the regulators and the manufacturers so that it could be further developed for Hungarian conditions and maximum use of made of scarce safety analysis resources.

2.2 Project Team

In meeting the needs of the project, SRD felt it was important to include experts from a number of different areas, including a team member from the HSE to reflect regulatory experience in the UK and a native Hungarian speaker with knowledge of hazard assessment.

Thus a multi-disciplinary project team was assembled consisting of a number of senior staff members at SRD as well as experts from outside. The team members were:

- Dr Andy Garlick, Manager of the Risk Management Department at SRD, Project Manager with responsibility for communications and overall development of the methods:
- Dr Ivan Vince, ASK Consultants, responsible for the provision of knowledge and expertise on the Hungarian situation, communications with and in Hungary, and for reviewing the work;
- Dr Steve Porter, HSE Principal Specialist Inspector (specialising in assessments of chlorine installations), responsible for specialist advice on risk assessment and regulatory conditions in the UK;
- Mr Barrie Blackburn, Manager of the Safety Management Systems Department at SRD, with responsibility for safety management advice and assessment;
- Dr Mark Eddowes, Environmental Risk Assessment Department at SRD, with responsibility for advice on environmental aspects;

- Mr Russ Ralph, European Business Development Manager at SRD, with responsibility for commercial, technical and logistical advice.

The team was able to provide expertise in all the areas relevant to the project.

2.3 Initial Visit and Task Breakdown

The initial information gathering took place during 24-27 November 1992 when Dr Garlick, Dr Vince and Mr Ralph visited UNIDO in Vienna and then held a number of meetings in Hungary. The purpose of the visit was to set up the contacts for the project and collect the information necessary for the team to plan the remaining tasks. An important aspect of this was the arrangements for a trial implementation of the methodology - known as the pilot study - in Hungary. This was to be an assessment of the chlorine plant at BVM in Budapest.

Following the visits it became clear that there were three somewhat different expectations of the project:

- SAFEORG wished to acquire a risk assessment methodology consistent with the Seveso Directive;

- BVM required a safety report for their chlorine production and storage plant which contained quantitative detail and which provided useful recommendations for BVM and the local authority; and

- the Ministry of Industry and Trade expected advice and recommendations on setting up a regulatory system for major hazards.

The project team attempted to meet all these expectations to the greatest extent possible within the limited time and budget available and the approach to each is set out individually in the three sections which follow.

3 DEVELOPMENT OF THE OSD METHODOLOGY

3.1 OSD Requirements and Approach

As noted in section 2.1, the outline safety document is intended to:

- meet all the requirements of the Seveso Directive for a safety notification, including those anticipated in the future;
- adopt a risk assessment approach modelled on the situation in the UK;
- be straightforward to apply, and provide maximum value for the effort expended.

A detailed analysis of the Seveso Directive was provided in the interim report [3] and is not repeated here. The requirements for a safety notification apply to a specific *industrial activity* comprising certain listed *processes* or *storage* which involve certain listed *dangerous substances*. The notification should be submitted by the *manufacturer* to a *competent authority* who will receive the notification, review it and inspect against it. Because the notification covers the fairly straightforward collection and presentation of certain information, the OSD methodology focuses on methods to do this.

Because the information collected in our approach is that relevant to the basic safety characteristics of the plant, it can be used in two ways.

- It can be analysed and collated in such a way that it provides a coherent argument that the plant is operated safely. This is the safety justification (or safety report, or safety case) that is required for the Seveso Directive notification.
- It can be analysed in such a way that it identifies the weak points in the hardware systems and the management of safety at the plant and can be used as a tool to improve safety and environmental performance. This is the safety assessment function.

It is intended that the OSD should be used for both functions. We envisage that flexible use of the OSD technique in Hungary will enhance the value to be gained from its introduction. Indeed we think that the OSD could be used jointly by regulators and manufacturers to gain familiarity with these techniques in a cooperative assessment (rather than regulatory) mode of operation which can then be evolved into a more independent, adversarial approach as Hungary moves towards membership of the EC with a consequent requirement to introduce a system compliant with the Seveso Directive.

The approach to information collection and analysis which has been adopted is one in which a set of standard forms are completed in such a way that when they are collated they form a complete OSD.

Associated with the forms is extensive guidance, using checklists in particular, which helps the analyst to provide the appropriate information and then to carry out the necessary tasks to establish the adequacy of the arrangements, and the risk presented by the activity.

In formulating the method the main inputs were the Seveso Directive itself and the guidance issued by the HSE in connection with the CIMAH Regulations. However, the OSD does not necessarily comply with all aspects of HSE guidance.

In particular changes have been made to facilitate the collection of information by the use of forms. Furthermore, the OSD method was developed to particularly address safety management (by the use of a small safety management audit) and environmental effects. For these we have drawn on the knowledge of SRD experts as to best practice in this area.

3.2 OSD Structure

Figure 1 shows the basic information processing which takes place for the OSD. It is based around the schedule of information which is set out in the Seveso Directive.

The key areas are those in the second row which represent the basic data collection requirements split into three main segments:
- information about the industrial activity,
- information about the management of the activity,
- information about the hazards arising from the activity.

Forms have been generated which assist the user to compile the information relating to each of these key areas. It should be noted that the second area - information about management - is not a Seveso Directive requirement. However it is incorporated in the CIMAH Regulations in the UK, and is expected to become a part of the Seveso Directive in the near future.

The data collection forms are described in more detail in the following subsections.

3.2.1 Definition of scope

A: IDENTIFICATION

> This identifies the industrial activity or activities and their associated installations to which the report applies and the basic information concerning the manufacturer and so on. An OSD may be prepared for a complete site, or for a subset of activities on the site. Form A also provides information on the contents of the OSD and its issue status.

B: APPLICABILITY

> This identifies the dangerous substances associated with the activity and their quantities. The Seveso Directive sets threshold inventories for a number of dangerous substances. If these thresholds are exceeded, a safety notification is required, though for the time being other criteria could be used for an OSD in Hungary. The OSD form helps the user establish whether a safety notification would be required under

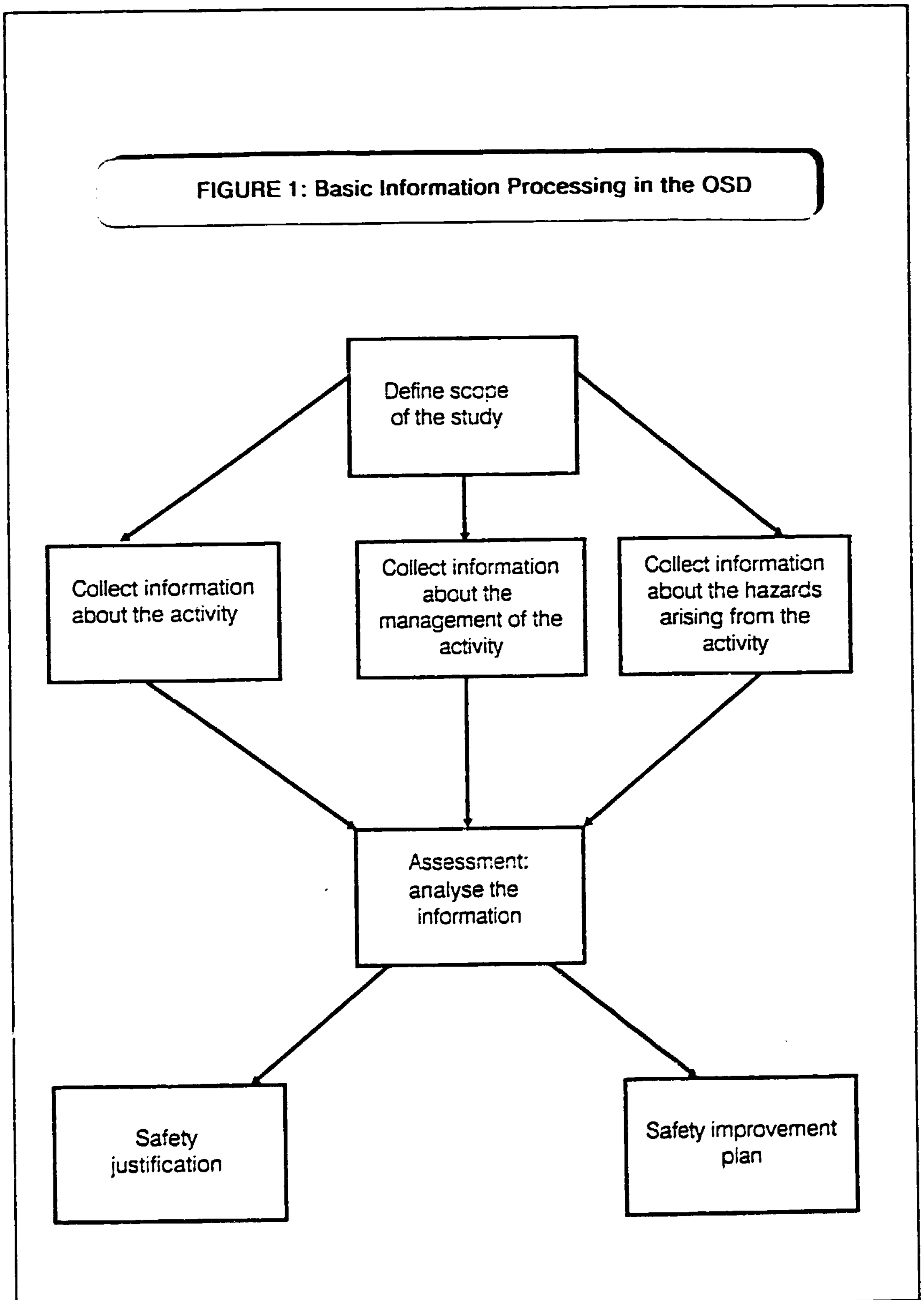

Figure 1 Basic Information Processing in the Outline Safety Document

the Seveso Directive and provides further guidance regarding substances which are environmentally harmful.

3.2.2 Information about the activity

Section C of the OSD collates all the information relating to the installation and its surroundings which is needed to develop and present the safety justification. It is broken into three separate forms.

C1: LOCAL INFORMATION

This information includes the location of the surrounding population, transport routes and environmental targets, the off-site emergency plans and the information provided to local residents concerning the industrial activity and its major hazard potential.

While it is not normally the responsibility of the manufacturer to prepare the off-site emergency plan, it is a Seveso Directive requirement that a system is in place for one to be prepared - normally the responsibility of local authorities - and the competent authority must check this. By including it in the OSD we are providing a means whereby this is reviewed, especially for the adequacy of the plan in the light of the hazards which have been identified.

Similarly the questions concerning information provided to the public are stimulated by the Seveso Directive requirement that such information should be provided. The information required is based on the related schedule in the Directive.

C2: SITE INFORMATION

This information includes the lay-out on-site, the details of the activity, and the measures taken to prevent, control and mitigate incidents, including the on-site emergency plan. Thus it particularly focuses on the safety-critical systems.

C3: HISTORY OF THE INSTALLATION

This information relates to accidents, near misses, reliability problems and management failures which have been experienced. This information is not required to be provided by the Seveso Directive, and it is not component of the CIMAH regulations either. However, the information can be used to justify estimates of frequency provided in the risk assessment and also provides a useful perspective on the safety management. We therefore recommend that it is retained within the OSD methodology.

3.2.3 Information about the management of the activity

Section D of the OSD contains information about the management systems. It too is split into three areas, but an additional form, Form D, is provided to collect information about the staffing arrangements and to give an oversight of the information collected using the other forms.

The Seveso Directive does not require this information to be provided in a notification. However the method developed here is based on the guidance given on the CIMAH

Regulations and thus represents UK thinking, as outlined in section 2.1. Furthermore it is likely that more detail on safety management will required when further amendments to the Directive are made.

Overall, this section can be dropped completely if Seveso Directive compliance is the main aim. Alternatively the main form, Form D, can be completed, leaving out the supporting details provided by forms D1-3.

D: INFORMATION RELATED TO THE MANAGEMENT SYSTEM

The purpose here is to determine the quality and completeness of the management of safety at the plant. Without a good standard of safety management the risk posed by the plant will be much higher than normally estimated. This form contains three main areas: staffing, control systems and training, and is filled in with the help of three subsidiary forms.

D1: STAFF INFORMATION

This establishes the details of the responsibilities of individual staff members for safety and the initiation of emergency plans. It includes not only those with direct line responsibilities, but also those responsible for providing safety-related technical support.

D2: CONTROL SYSTEMS AUDIT

This is an audit technique which provides a basic overview of the safety management systems most relevant to major hazards. The results are condensed into an overview report on Form D. The control systems covered are: engineering control (design, modifications, maintenance, hazardous work), operational control (procedures for normal, abnormal and emergency operations) and materials control (including security).

D3: TRAINING AUDIT

This is a further audit aimed at establishing that systems exist to ensure that staff involved with safety functions are properly qualified and trained. Again it is summarised into an overview on Form D.

3.2.4 Information about the hazards arising from the activity

Section E of the OSD deals with hazard identification and analysis, again broken down into three stages. The focus of this is potential major accidents, in accordance with the Seveso Directive, but the techniques used are also useful for generating information about all kinds of hazards including occupational ones.

E: ASSESSMENT METHODS

The first form in Section E is used to collect details of the approach to the assessment and the methods used in each of the subsequent sections. This includes the methods used to identify hazards and also the methods used to analyse the likelihood and consequences of accidents.

E1: SUBSTANCE INFORMATION

This enlarges on the basic inventory information about dangerous substances previously given on Form B. It sets out the conditions under which the substance is used in the activity and what the hazards associated with it are.

E2: IDENTIFICATION OF HAZARDS

This leads the analyst through a procedure for identifying the hazards associated with each dangerous substance in the industrial activity. The endpoint is to identify those hazards which have the potential to lead to a major accident and guidance is given on deciding this. However, the methods can also be used to identify other hazards, such as the occupational safety problems on the plant.

E3: ASSESSMENT OF POTENTIAL MAJOR ACCIDENT

This form is completed for each potential major accident identified at the previous stage. It leads the user through a classification of the accident, ways to derive qualitative estimates of likelihood and consequence, and if necessary quantitative methods. In particular it provides a method for estimating accident frequencies based on generic failure rates used by the HSE. It also gives guidance on sources of methods for calculating the consequences of accidents. It does not directly provide methods for doing this; this is a very complicated area beyond the scope of this project. In this respect the OSD may not be fully Seveso-compliant on its own since consequence calculations are necessary not only to estimate risk, but also to design on- and off-site emergency plans.

3.2.5 Analysing the information and assessment

F: CONCLUSIONS

This is the final form in which the results of the major accident assessments, and the other information compiled during the assessment are drawn together. It provides guidance on calculating and presenting the risk information.

As shown on Figure 1, the outcome of the assessment depends on the purpose for which it is carried out. For a safety justification, this is where a statement of adequate safety should be made. However, the question of what standards are to be applied in Hungary, for example in terms of tolerable levels of risk, is beyond the scope of the project. For a safety assessment it would be expected that an action plan agreed by management would be set out, or the assessor's recommendations on possible improvements.

3.3 OSD Presentation

The OSD methodology was fully developed prior to the pilot study in the form of two separate documents: a set of forms as described above, and a guidance document.

The guidance document sets out in some detail what is required and relates the requirements back to the Seveso Directive explicitly. It is possible that too much detail is contained in the guidance of this general nature, but it does help the user assess compliance with the Directive. The guidance is heavily based on guidance provided by the HSE for the CIMAH Regulations [2] as well as on SRD's views on best practice in safety assessment.

There are many possible options for presenting such a system. They include binding the guidance in with the relevant forms - perhaps on facing pages, using different colours, as form header sheets, and so on - and different ways of using the forms.

In fact it was decided to keep the guidance as a separate volume (well indexed) printed on normal paper (the trial version was pink). It is Annex 1 to this report. This makes alterations and additions as easy as possible.

The presentation of the forms is also difficult. Forms are ideal for handwritten or typed reports but can become difficult to manage using word processors. The alternative might be simply a contents list. However, this depends on the technology available to the user and is simply left as an option. The data entry forms are therefore one of the deliverables of the project - see Annex 2, but may be used in whichever way is convenient as a guide to how to present the assessment.

3.4 OSD Features

This sets out a number of particular features of the OSD methodology.

3.4.1 Document control

The OSD forms are provided with a means of document control which tracks the issue status of each form, and the backup documentation which is attached to it. They are also provide with header information to identify the forms and their contents easily. Finally each form contains a box allowing the relevant responsible person to approve their contents. It may be decided that all of this is too elaborate for the current stage of development, in which case it could be removed.

3.4.2 Safety management information

It was noted previously that two main parts of the safety management information collection consisted of audits of the systems. The intention is that such audits represent a relatively straightforward way of collecting important information, though some training and experience would be required before the audits could be carried out by a new user. These audits were extracted from SRD's own safety audit system, PRISM. They represent a very small subset of the total contents of PRISM as they would of any audit system. They are designed to give an indication of the quality of the management system, rather than to be a check of the systems' completeness and adherence to best practice.

3.4.3 Hazard identification

It is recommended that hazard identification be carried out using the HAZOP technique. This has been applied for many years in the chemical process industry as a tool to examine detailed plant designs for hazard and operability problems [4]. More recently these techniques have been adapted to provide higher level examination of safety problems at both the design and operating stage, and it is this approach that is recommended.

The fundamental property of the HAZOP technique is that involves plant experts of different skills and backgrounds in a group meeting with a chairman who is experienced in the technique, but not necessarily in the plant to be studied. This generates a probing atmosphere for the group session which allows "how?" and "what if?" questions to be asked which then reveal previously unsuspected aspects of the plant behaviour.

Again the intention is that this area of information collection should be relatively straightforward (though again some training, of chairmen and secretaries, is necessary).

3.4.4 Risk assessment

Risk assessment can be carried out at different levels. The guidance notes and forms include three levels of likelihood estimation and two of consequence calculation. For both parameters it is possible to carry out a categorisation using basic knowledge of the hazards. It is also possible to do detailed calculations of frequency and consequence and the guidance notes provide reference lists on doing this. A third method of frequency estimation is provided which is used by the HSE in assessing plants for land use planning purposes. This depends on using a set of generic frequencies (validated in the UK) relating to releases per unit pipe length, per vessel, etc. This formalised method provides a useful way of comparing the different plants, though its absolute accuracy is open to question. In the future it would be appropriate to begin to calibrate such methods for Eastern Europe; this could come at a stage prior to developing a full database.

The categorised methods may alternatively be applied following the hazard identification stage.

At the conclusions stage further guidance is given on how to evaluate risk on the basis of the likelihood and consequence information for each accident.

3.4.5 Environmental Aspects

One of the key areas identified by UNIDO in their original request was the ability to analyse accidents causing environmental harm. The study of such accidents is much less developed than for accidents harming man and this caused some difficulty in the project. Specific guidance on environmental aspects was written into each section of the guidance notes. However, this is not required by the current version of the Seveso Directive, and it appeared to detract from the flow of the guidance generally. As it did not affect the information to be provided on the forms, most of the environmental guidance is now incorporated into an Appendix to the guidance.

4 THE PILOT STUDY

4.1 Scope of Pilot Study

The industrial activities selected by SAFEORG for the pilot study were the production, storage and shipment of chlorine by Budapesti Vegyimuvek (BVM) at its Illatos ut site in South East Budapest. This site experienced an explosion in January 1992 and we understood that as a result the local authorities of Budapest IX were taking a particular interest in the activities carried out there. In fact a safety study has already been carried out by SAFEORG but this did not include the chlorine processes. Thus BVM had a particular interest in having a study done which covered this.

In fact, at the meeting in November, BVM made clear their need for a detailed report and mentioned their wish to see quantified levels of risk to members of the public and to workers. In the case of workers it would be unusual to prepare a risk assessment based purely on major accidents: a large contribution would be expected from normal industrial accidents. In the case of the public we agreed to attempt to estimate the risk for some accidents, and this extension to what is strictly required for the OSD was also requested by UNIDO.

The process consists of two sets of electrolytic cells where chlorine gas is produced from brine at up to 3 te/hr. The chlorine is compressed and condensed, following which it is stored in tanks. There are four tanks each containing up to 25 te of chlorine. The chlorine is shipped off site in railcars (up to 40 te), drums (up to 1 te) and cylinders (50 kg) and is also used on-site in the organics plant and for the manufacture of sodium hypochlorite and hydrochloric acid. The hypochlorite plant is an important safety system, extracting routine and accidental chlorine releases.

The Illatos ut works are in a generally industrial area of Budapest, surrounded by marshalling yards, other industries, and wasteland. However 300 m from the plant in a south easterly direction (down the prevailing wind) is an area of dense housing. The works are also about 1 km from a branch of the Danube.

4.2 Schedule of Pilot Study

Following the November meeting, requests were made to SAFEORG for information concerning the activity, and a considerable amount was received. This was mainly in Hungarian and this impeded assessment of its utility. Thus the contents were scanned and further requests made for information that appeared to be missing.

In order to deal with this problem during the main part of the pilot study, SAFEORG made two English-speaking technical assistants available. These were Mr Jozsef Szamosi and Mr Peter Pal; they acted as translators and searched out information which was not readily available.

The main pilot study took place during the week of 18-22 January 1993. During the week the following activities took place.

Monday 18 January
Activate office at BVM, install computers etc, initial briefing meeting with BVM management and staff, start of high-level HAZOP of all plant covered in the study, safety management walk-round.

Tuesday 19 January
Safety management interviews, remainder of HAZOP, arrival and familiarisation of Dr Porter.

Wednesday 20 January
Continuation of safety management interviews, inspection by risk assessment team, collection of local information.

Thursday 21 January
Continuation of safety management interviews and report preparation, preparation of risk assessment, meeting between Dr Porter and MIT representatives (described in Section 5).

Friday 22 January
Meeting to discuss detailed results of inspections with BVM management, meeting to discuss overall conclusions of study with all interested parties (BVM, local authorities, MIT, and the civil defence authorities).

Throughout this period the team received excellent co-operation from the BVM staff involved. They went to considerable trouble to provide information and kept long working hours, having arrived well before us in the morning. The efforts of the two technical assistants were particularly commendable, with a requirement to translate continuously in both directions throughout the day.

The above schedule is in line with the planned schedule provided in the interim report [3]. The main difference is that 1.5 days were used for the high-level HAZOP and the detailed HAZOP of railcar loading was abandoned, though this has little effect on the assessment.

The Friday morning meeting was used to indicate a number of areas where BVM management could improve safety performance and these suggestions were well received. The Friday afternoon meeting was used to provide a more general description of the method and the results. Although quantitative risk figures were available, shortage of time meant they had not been checked or agreed within the team, and this information was therefore not presented.

Following return to the UK the results have been written up and are presented as Annex 3 to this report.

4.3 Conclusions of Pilot Study

The Illaros ut works are very old - of order 100 years - and the chlorine production process also dates back many decades. We were told that throughout this time attempts had been made to move this activity from such a populated area. The condition of the buildings and the plant reflects this age: they are decaying, dirty and not well kept.

The equipment itself is also old, furthermore it was complex and completely dependent on operator actions. There was therefore considerable scope for operator error; indeed this had caused the previous year's explosion and by examining the incident records for a five year period we found several serious incidents stemming from this. There were very few automatic systems and no chlorine detection systems. The equipment associated with chlorine shipments was particularly basic.

We found that the hazards of the process were generally well understood and that many systems were apparently in place for the management of safety-related activities such as maintenance, storage tank inspection, etc. However it was not apparent that these systems were adhered to. We found many insufficiently supported pipes, evidence of maintenance carried out to poor engineering standards, availability of materials which react with chlorine, unwise working practices, failure to adhere to instructions and a general failure to realise the propensity for human error. While there was both an on-site emergency plan and an off-site one in the final stages of preparation following the explosion it was clear that these plans would not work if called on.

It was also clear that a number of more routine occupational hazards, involving the use of mercury, unprotected machinery and falling hazards, existed. There were several grounds on which continued operation would not have been permitted in the UK.

It was a matter of further concern that we were given two inconsistent piping and instrumentation diagrams prior to the main study, and that on arrival at BVM we were presented with the "correct set" which had clearly been prepared specifically for the study. We identified a number of errors on these. Similarly when we requested the procedure for rail car loading, a new one was specifically written.

As a result of these shortcomings the team were able to make a number of recommendations to BVM management which, if implemented, would considerably improve the safety of the activity. Further details are contained in Annex 3. Many of these recommendations provide a very cost-effective way of improving the safety levels at the plant compared with the replacement of the old equipment.

Failures to manage safety to UK standards also mean that the risks to the public will be higher than estimated using UK generic data.

A quantitative risk assessment was carried out using a limited number of release scenarios and grouping into categories to reduce the number of calculations. Both individual risk and societal risk were calculated. Individual risk is the likelihood of receiving a particular toxic dose and societal risk is the chance of accidents in which a given number of people receive a given dose. Two doses were considered: that used by the HSE in the UK which is the level at which the most susceptible members of the population may be killed, and the dose at which around 50% of the population will die. The former is more relevant to individual risk and the latter to societal risk.

The risk calculations did not take into account the effects of being indoors, nor did they model countermeasures such as evacuation. However the risk levels found were high by the standards currently under discussion in the UK. These levels could be considerably reduced if the recommendations for improved safety at the plant were put into effect.

4.4 Lessons for OSD Methodology

The main tasks carried out during the week in Budapest were the three items of data collection shown on Figure 1. As has been noted, these tasks are intended to be relatively straightforward to carry out, with a minimum of specific safety assessment knowledge. In fact a high-level HAZOP of the process was completed in about 12 working hours, including translation. A further 6 hours of inspection was carried out, meaning about 90 man-hours of work for hazard identification.

The was difficult in several ways: the obvious one was the translation, but there were also problems in developing the desired group dynamic. In general it consisted of the chairman asking the what-if questions, with the answers mainly being given by just one of the plant people present. Thus it was more interview than group session. No doubt with time and a shared language a better team spirit could be developed. We feel the technique could be introduced with no problems, though some training may be required.

A similar picture emerges from the safety management interviews we held. A similar number of man hours was involved in these and a considerable amount of information was gained, though in many cases not checked. It is important to remember that this is not intended to be a complete assessment: what was required was an overview of the standard of safety management and the sessions held were quite adequate to do this, as well as allow positive suggestions fro improvements to be made. Again, though, training would be desirable to allow assessors to reach the required standards.

With regard to the basic data collection, we were able to obtain most of what we needed, though there were difficulties with the off-site emergency plan because of its status. The fact that material was prepared especially for the study has already been mentioned. It was very difficult to get adequate maps for the purpose of the study: in the end we made composite maps which showed both plant details and the local surroundings. And we collected some of the information required by walking around the neighbourhood with a Polaroid camera.

Overall, the information collection was demonstrated as feasible with the timescale, and as not requiring a high level of technical expertise. Furthermore this experience has not led us to make more than detailed changes to the OSD methodology in the relevant areas. Interpretation of this information is a more expert task, but many constructive suggestions were made by the safety experts on the team which would have the effect of making significant improvements in safety and environmental performance.

In the risk assessment area we were also able to make simple quantitative estimates of risk. These estimates used many fewer releases than is normally the case in the UK and the uncertainty introduced by this is not known, but will be less than an order of magnitude. However the main source of uncertainty is in the release frequencies where the use of generic UK data in Hungarian conditions is questionable, especially where there are demonstrated deficiencies in safety management. Not surprisingly with such a complex plant the risks off-site that we estimated are high by UK standards, and could be reduced significantly if the suggested improvements are introduced. This emphasised our view that QRA is of limited application in these circumstances. The main priority should be to identify the hazards and check that they are controlled. We can echo Kletz's [4] comment that hazard analysis is a waste of time if the plant is not designed, operated and maintained according to good management and engineering standards.

Finally it should be noted that the pilot study has given us very little information about the feasibility of looking at environmental harm using the OSD methodology, although the team did collect information about some problems in the area, including mercury contamination for which BVM are fined at regular intervals. We recommended that a mercury mass-balance study be carried out.

5 ADVICE TO REGULATORS

5.1 The Regulatory Environment in Hungary

The current climate for the regulation of safety and the environment in Hungary is highly volatile. The need to move to more appropriate systems with the advent of new social, economic and political standards is only now having an impact in this area, with the situation being complicated by the desire to be able to implement EC directives on joining the Community.

This has led to much discussion on the best way to regulate labour, public and environmental safety and how ministerial and executive responsibilities should be organised. Our main Government contact in Hungary, the Ministry of Industry and Trade, is in the thick of these discussions. It is one candidate to take responsibility for a new regulatory organisation which would have the competent authority role required by the Seveso Directive.

5.2 Interactions with MIT

The staff at the Ministry of Industry and Trade met by the project team in November saw the main immediate benefit of the project coming from the opportunity to learn from experience in the UK of the implementation of regulations in the area of major accident hazards, and in particular the Seveso Directive. The areas in which MIT could benefit from advice directly relevant to Seveso were listed in the interim report [3]. It was anticipated that much of this benefit would come from the presence in the project team of Dr Porter from the HSE who held a half-day meeting with MIT personnel on 21 January.

As noted previously the MIT personnel also requested a visit to HSE to observe how the Executive operates at both a policy level and on a day-to-day basis. Arrangements for this are in place, but lie outside the scope of this project.

The meeting with MIT was attended by 16 people representing a number of Hungarian Government departments and industry organisations including the Ministry itself, the Ministry of Labour, the Ministry of the Environment, the Chemical Inspectorate, SAFEORG and others.

Dr Porter gave a presentation on the HSE which covered the historical background, legal framework, objectives and function.

Given the radical changes taking place in Hungary there was much interest in the legal and institutional development of the HSE, as well as constitutional issues in the UK. Clearly this stemmed from MIT's interest in setting up a similar regulatory body.

Mr Somogyi of MIT, who may be responsible for major hazards in the future, prepared some notes on the presentation which are attached as an Appendix. They illustrate the interest of the Ministry, but show that at present it is at a rather basic level.

During the meeting it was apparent that MIT staff were heavily involved in dealing with parliamentary questions on where the responsibility for these areas should fall. In this atmosphere there was naturally some distraction from the visit and presentation by Dr Porter. Although there were significant levels of interest generated amongst those present there was no one at the meeting who would have a significant part to play in the decision making process.

As a result it was apparent that the initial plans were over ambitious and that it was not possible to provide advice on the detailed issues that were anticipated. What was important was that the underlying philosophy of the UK approach to major hazard regulation was communicated, and that there will be opportunities in the future to give advice on the more technical aspects if this is required. Furthermore, once the position on safety and environmental responsibilities is clarified it will be important for the competent authority to have available appropriate levels of technology, including risk assessment codes and training.

One area that was raised which lies outside HSE's scope of activities was trading standards for product safety and certification. MIT in particular were interested in the systems in place in the UK and their legal framework. Those members of the project team present were not able to give a full account of the UK position in this area. However, as this was a major safety consideration for the public, it was agreed that visits would be arranged with relevant officers from the UK Trading Standards Service during MIT's visit to the UK to see the HSE.

6 CONCLUSIONS

(1) An outline safety document methodology has been developed which can be used to justify the safe operation of major hazard plant or to assess its safety. The methodology is supported by a set of data entry forms and associated guidance notes.

(2) The methodology comprises three relatively straightforward data collection tasks - information about the plant itself, the hazards it leads to and the way those hazards are managed - followed by an assessment task. Leaving aside the comparatively complex topic of quantified risk assessment, the assessment task is also straightforward.

(3) The methodology can be applied to a substantial industrial activity in Hungary with several man-weeks of work, including the need for virtually 100% translation.

(4) It follows that with appropriate training and experience the methodology can form the basis for introducing modern goal-setting risk management techniques into Hungary in a timely and cost-effective way. This in turn can support a regulatory scheme for major hazards which would meet the requirements of the Seveso Directive.

The areas where further assistance to Hungary is indicated are as follows:

- training in the OSD technique (in an agreed final form), and possibly in more advanced QRA techniques;
- training in safety management techniques, including the introduction of safety management systems, carrying out safety audits, and the development of emergency plans;
- similarly, training in environmental management techniques;
- specific assistance to BVM in the above areas;
- development of failure databases relevant to Hungary (and possibly other parts of Eastern Europe);
- development or purchase of risk assessment and consequence analysis tools for use in Hungary, and training in their use;
- advice on risk management techniques, particularly regarding tolerable levels of risks and reducing risk levels to as low as reasonably practicable (a UK legal requirement); and
- advice to Hungarian regulators on the philosophy and detail of setting up a competent authority for the regulation of major accident and environmental hazards.

7 REFERENCES

[1] Seveso Directive, 82/501/EEC, (1982) OJ L230, p 1, as amended by 87/216/EEC, (1987) OJ L85, p 36 and 88/610/EEC, (1988) OJ L336, p 14.

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APPENDIX: MIT Meeting Notes

Translation of a note by Mr J Somogyi. A number of further details are provided in footnotes, based on comments from Dr Porter.

SUMMARY NOTES OF DISCUSSION

HELD AT MIT, ROOM 553, 21 JANUARY 1993

Subject:	Presentation of UK Inspectorate concerned with "dangerous" industries.
Presenter:	Dr Stephen Porter, Principal Inspector, UK Health and Safety Executive (HSE)
Those Present:	See list attached.
Interpreter:	Dr Ivan Vince, ASK Consultants

Introduction

SRD Safety and Reliability Consultants, a British firm, is carrying out a study on behalf of Hungarian institutions under the auspices of UNIDO. The subject of the study is "Safety and economic quantitative risk assessment (QRA) technique" [sic]. Dr Stephen Porter, HSE Principal Inspector was involved in the project. Since QRA activities are closely connected to the work of inspecting authorities, it was decided, as part of the project, to hold an introductory seminar on the practice of industrial safety regulation in the UK, which is largely the province of the HSE.

Status of the HSE

The HSE was formed in 1974. Previously, there had been the Factory Inspectorate, set up in the last century, originally for the protection of children (child labour); even in more recent times, its sphere of influence was restricted to the factory fence. The possibility of accidents leading to off-site consequences, and the need to bring worker health protection, worker safety and environmental protection under one umbrella, led to the formation of the HSE.

The legal framework within which the HSE was to operate was provided in the Health and Safety at Work Act (HSWA) of 1974. Under the terms of the Act, a committee, the Health and Safety Commission (HSC) is responsible for the Executive. The HSC numbers 10-15 people nominated by the Employment Minister from representatives of employers, employees, local authorities and, recently, consumers.

The executive organ carrying out the tasks of the HSC is the HSE, which consists of a number of central institutions and 21 regional organisations, with a total staff of 3000 - 4000. (The 1992 expenditure for the HSE was £194 million, which was provided from the national budget.) In some specialist areas (fire, explosion, dense gas dispersion, etc), the HSE operates its own research institutes[1].

Duties and Functions of the HSE

Relevant regulations are published by the HSC, using its powers under the terms of the HSWA. (This has the added advantages that the HSC can implement the relevant EC Directives without the need to involve Parliament.)

The HSE ensures that regulations made by the HSC are brought into effect. The HSE can give compulsory instructions to any parties affected by the regulations. HSE inspectors are generally graduates, while specialist inspectors are required to have relevant further education/experience.

Under the terms of the HSWA, inspectors can demand practically any information from the site operator. The main goal of the HSE is to prevent or mitigate off-site risks[2]. On-site safety is basically assured by the site operator/owner by following the regulations (the HSE takes part in drafting the regulations); but the HSE is not essentially involved in this (presumably this is more a subject for insurers, including National Insurance). The most important function is the prevention of the major accidents (literally, "catastrophes"), the elements of which are:

- hazard identification and assessment,
- hazard minimisation and control (the ALARP principle),
- mitigation of consequences in case of realisation of the hazard (land use planning, emergency planning).

Planning permission is generally a matter for the local authority (LA), but for this the LA requires a plan from the developer, which it makes public, and concerning which it consults the HSE. The HSE considers individual planning applications free of charge on behalf of the LA.

The HSE can call in planning applications for especially hazardous plant, and in these cases the Environment Minister decides.

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[1]HSE also carries out or sponsors research on occupational causes of ill-health, including noise, vibration, exhaust ventilation, exposure to toxins and other topics such as railway and fairground accidents.

[2]This is main task of the HSE's Major Hazards Assessment Unit. The remainder of the HSE are involved in the enforcement of on-site health and safety matters.

UK Practice and its Relation to EC Regulations

UK practice conforms to EC regulations. The EC Seveso Directive has been in force under HSE control since 1984 (the British version goes under the name CIMAH). In the UK, approximately 1600 sites are governed by Seveso, of which approximately 500 are classed as top-tier, and require operating permits to be renewed every 3 years (or after any modification)[3]. The risk assessment prescribed by Seveso may be carried out in the UK by any institution (including consultancies), but HSE prefers reports to be prepared by the hazardous firm itself.

All EC Directorates[4] have HSE representatives on their safety committees, so UK practice is in turn embodied in the evolving EC regulatory framework.

[3]The HSE do not in fact issue permits to operate a major hazardous chemical plant, but the company needs to have submitted a safety report and have it reviewed by the HSE every three years or when there has been a significant plant modification.

[4]Only those which have responsibility for health and safety legislation. This is merely to influence the EC legislation along the lines of the British model. It is not always the case that the resultant EC legislation is fully influenced.

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SRD

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OUTLINE SAFETY DOCUMENT FOR MAJOR HAZARD PLANT IN HUNGARY:

ANNEX 1

GUIDANCE NOTES

Prepared by SRD
February 1993

AEA TECHNOLOGY

Foreword

These notes accompany a set of forms which guide the user through an assessment of the safety of industrial major hazardous plant. Such an assessment will be compliant with the notification requirements of Article 5 of 82/501/EEC - the Seveso Directive. Extracts from the Directive have been set out in the notes in double edged boxes.

The approach chosen has been heavily influenced by that of the Health and Safety Executive in the UK. However, this does not imply approval by the HSE of the methods and guidance set out here, which is provided by SRD.

A R Garlick
SRD
February 1993

CONTENTS

OVERVIEW

Purpose

Article 1 of 82/501/EEC[1] - the so-called Seveso Directive - begins as follows:

> This Directive is concerned with the prevention of major accidents which might result from certain industrial activities and with the limitation of their consequences for man and the environment.

The Directive sets out a number of measures which have to be implemented in Member States in pursuit of this end. In particular Article 5 requires:

> Member States shall introduce the necessary measures to require the manufacturer to notify the competent authorities ... if in an industrial activity ... one or more ... dangerous substances ... are involved. ... The notification shall contain the following:
> (a) information relating to substances ...
> (b) information relating to the installations ...
> (c) information relating to possible major-accident situations ...

This "notification" is the safety report which plays a major role in managing major accident hazards in the EC and is now coming into play in other arenas such as offshore oil and gas exploitation in the North Sea.

The Outline Safety Document (OSD) is intended to fulfil the role of the safety report for Hungarian conditions. It is intended to be relatively easy to apply and assess, and to be fully compliant with the requirements of the Seveso Directive. Beyond this, it contains some additional features which are intended to:

- test compliance with the Seveso Directive in some areas which are not strictly the province of the safety report;
- anticipate future changes in the Directive;
- provide a more complete treatment of environmental major accidents;
- emphasise the role of safety management in the reduction of risks.

This methodology for preparing an OSD has been designed to be as straightforward as possible, minimising the knowledge of safety and risk assessment techniques required. Nonetheless, a basic understanding of the principles will be needed, as will access to a number of documents setting out the more detailed techniques. It is assumed that the assessor will be familiar with the plant to be assessed.

Structure

The OSD is structured as a compilation of relatively small documents. Thus it can be expanded at will. The documents largely consist of a series of forms to fill in, though additional material is required in some areas. A document control system to reflect modifications to the document is provided. This ensures the status of the document and the plant it refers to are well understood and is described in more detail below

This guidance could be printed on coloured paper, enabling it to be interleaved with the OSD if required, and later removed from the document if necessary. In the present version it is presented as a standalone document. The guidance is intended to provide immediate support needed to the person compiling the OSD and can also be used during an assessment. Furthermore it shows how the contents are related to the requirements of the Seveso Directive and how this has been expanded to reflect anticipated future changes in the Seveso Directive or what SRD believes to be good practice in providing an assessment or justification of plant safety.

Detailed guidance on environmental issues has been included as an Appendix.

The contents of the OSD are the following:

A: IDENTIFICATION
B: APPLICABILITY
C: INFORMATION RELATING TO THE INSTALLATION
- C1: LOCAL INFORMATION
- C2: SITE INFORMATION
- C3: INSTALLATION HISTORY

D: INFORMATION RELATING TO THE MANAGEMENT SYSTEM
- D1: STAFF INFORMATION
- D2: CONTROL SYSTEMS AUDIT
- D3: TRAINING AUDIT

E: INFORMATION RELATING TO POTENTIAL MAJOR ACCIDENTS
- E1: SUBSTANCE INFORMATION
- E2: HAZARD IDENTIFICATION
- E3: POTENTIAL ACCIDENT ASSESSMENT (for each potential accident)
- ....
- ....

F: CONCLUSIONS

In Section E a set of forms is prepared for each dangerous substance identified as triggering a notification under the Seveso Directive. This set of forms allows the hazards associated with each substance to be identified, and the potential major accidents they can lead to to be analysed in depth. This can be repeated for each substance or done for the whole of the industrial activity at once. It can also be done for any other hazards not necessarily associated with Seveso Directive dangerous substances.

Those parts of the Seveso Directive which set out the requirements of the safety notification are displayed in boxes in this guidance. This illustrates the minimal requirements to be compliant with the Directive. More specifically, sections C3 and the whole of D are not required if compliance with the Seveso Directive is the only aim. Furthermore it is not necessary to provide any information on the likelihood of potential major accidents in Section E3.

Format and Document Control System

The basic information for the OSD is supplied by filling in a series of forms. There may also be relevant additional material in the form of maps, drawings, organisation charts, more detailed analyses or existing documents. These are drawn together to form small documents which are then compiled into the larger document. A standard way of indexing the supplementary information is provided.

Each document has an issue number and a revision history. This enables changes made as a result of plant changes, improvements in technical knowledge and a need for fuller information to be absorbed in a controlled way.

The documents are compiled into the complete OSD which itself has an issue number and a revision history and, in addition, a contents list. Provision has also been made for formal approval of each part of the document.

Each form has a (more or less) standard front page which is now described; the remainder of each form depends on the information it contains.

Each form has a header which shows:
- that it is part of an OSD,
- an identification code,
- the name of the form,
- the industrial activity to which it refers,
- the page number,
- the number of the form if relevant,
- the issue number,

- the issue date,
- other information as required for specific forms.

Matters relevant to specific forms are described in the following sections of this guidance.

Sequential issue numbers should be used to reflect modifications to the OSD. It is suggested that drafts are numbered Draft A, Draft B. etc, and that only approved issues of the OSD are assigned numerals.

Each form except Form A begins with an attachment list which allows the user to reference any information which is part of the OSD but is not entered on the forms. Form A has a contents list instead, which allows the documents making up the OSD to be listed. (Further exceptions are forms C3 and D1 which are simple compilations of one page forms using a special header sheet.)

The front page of each form contains a revision history table. This can be kept as a running record. As each new issue is made the date of issue is entered along with a brief comment reflecting the reason for, and nature of, the change made. Typically this would be either: that the nature of the industrial activity had changed in such a way that the OSD was significantly inaccurate; or that a routine update had been made, perhaps to reflect increases in the state of technical knowledge; or that significant improvements in the safety justification had been made, perhaps at the request of the competent authority (regulator).

Finally, the front page contains an area where the person responsible for the form can sign to signify his or her approval of the contents.

The way in which the form is filled in is left to the discretion of the user. There are a essentially two options:

- hand- or typewritten entries on the forms, with attachments for items where insufficient space is provided;

- word processing of forms, in which case the spaces can be expanded (or contracted) to reflect the material inserted - this, however, can be tedious because of the complex header structure, which might be simplified.

Which route is chosen, and the precise details will depend on the resources available to the assessor and no guidance is given here.

References

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[32] Bretherick's reactive chemical hazard database, Butterworth-Heinemann Ltd, 1991

[33] Major hazard incident service (MHIDAS), available from HSE or SRD.

[34] Considerations for Chemical Process Quantitative Risk Assessment, Centre for Chemical Plant Safety Report, AIChE, 1989.

A: IDENTIFICATION FORM

The function of this Section is to identify the industrial activity to which the OSD refers. It also identifies the manufacturer, site and the person responsible for preparing the OSD. Finally it contains information on the current status of the OSD: its contents and revision history.

Industrial activity:

Fill in the name of the activity to be considered. The OSD may refer to one or more industrial activities; normally only one would be considered at a time though it may be beneficial to include several related activities on the same site. The precise Seveso definition of industrial activities is given in the guidance on Section B.

Manufacturer:

According to the Seveso Directive, Article 1:

> *Manufacturer* means:
>
> - any person in charge of an industrial activity.

Following UK practice, a "person" may be an individual, a corporate body or a company. Normally it would be the operating company that is filled in here, together with its corporate address.

Site:

This identifies where the industrial activity is carried out. In what follows, in accordance with UK practice [2], "site" means the whole of an area of land under the control of the manufacturer, including piers, jetties and similar structures, with a further definition for inland waters.

Purpose of assessment:

The safety report is normally required to provide a *justification* of plant safety to the competent authority. However, in the Hungarian situation, the introduction of these methods is at an early stage. Therefore an *assessment* may be carried out for other reasons: by regulators or others to test the viability or utility of the methodology, or by operators for internal use. Therefore the purpose should be explicitly set out here.

Responsible Person:

This is the person who is responsible for the OSD. His name, address and telephone number should be given. The person would depend on the purpose of the assessment set out above. For a safety justification it would be someone within the company with responsibility for safety documentation.

Industrial activity means:

- any operation carried out in an industrial installation referred to in Annex I involving, or possibly involving, one or more dangerous substances and capable of presenting major-accident hazards, and also transport carried out within the establishment for internal reasons and the storage associated with this operation within the establishment,

- any other storage in accordance with the conditions specified in Annex II.

Annex I [1] identifies various types of industrial installations, specified either in terms of their chemical or physical process, or the materials produced or being processed. Annex II contains a schedule of named substances and categories of substances and preparations which bring storage installations under the Directive. It is assumed that the assessor has access to these annexes.

Inspection of these Annexes shows that industrial activities come under the lower tier arrangements if a *process* involves any dangerous substance or if *storage* involves more than a threshold amount. However the upper tier requirements (for a notification) come into play:

if in an industrial activity as defined (see above), first indent, one or more of the dangerous substances listed in Annex III are involved, or it is recognised that they may be involved, in the quantities laid down in the said Annex, such as:
- substances stored or used in connection with the industrial activity concerned,
- products of manufacture,
- by-products, or
- residues

or if, in an industrial activity as defined (see above), second indent, one or more of the dangerous substances listed in Annex II are stored in the quantities laid down in the second column of the same Annex.

Thus a notification is required for *processes* if the amounts in Annex III are exceeded and for *storage* if the amounts in the final column of Annex II are exceeded.

The precise means of calculation in the case of storage are somewhat complicated. Good guidance is given in the HSE document on CIMAH [2], in the initial introductory chapter, and in the commentary on the relevant schedules. We shall not repeat this here since the main use of the OSD is likely to be for process installations initially. Annex II also refers to the EC Directives on the classification, packaging and labelling of dangerous substances. If the equivalent has been implemented in Hungary, the existing system can be used. If not it will be necessary to refer to these directives, or to some national implementation of them, [5] for example.

Is the industrial activity carried out in an industrial installation referred to in Annex I and involving one or more of the substances listed in Annex III?

If the answer is "yes", then it is process activity and you should go straight to the next table, if "no" answer the next question.

Does the industrial activity involve storage of one or more of the substances and preparations in Annex II?

If the answer is "no" omit the next table, if "yes" then it is a storage activity and you should fill it in.

Substances listed in Annex II and Annex III

Depending on whether this is a process or storage activity fill in the Annex III or Annex II substance names, followed by the stage of the activity they are involved in and the quantities. This is to fulfil the Seveso Directive Article 5 requirement that the notification should include:

> The stage of the activity in which the substances are involved or may be involved and the quantity (order of magnitude)

The maximum quantity of each dangerous substance liable to be involved in and associated with the activity should be given.

At this stage it is necessary to decide if further analysis of any of the substances is necessary. This depends on the purpose of the assessment, but is very likely to be the case if the amounts exceed the amounts in Annex III if it is a process activity, or if they exceed the amounts in the final column of Annex II if it is a storage activity. However it would also be advisable if the amounts are close to the thresholds, or if the OSD is to serve a lower tier purpose (in which case for storage activities the amounts in the middle column of Annex II might be relevant). For the initial trials it is recommended that the Seveso Directive amounts are used.

The decision should be entered as "yes" or "no" in the final column of the table.

Other dangerous substances

The substances in Annex II and III do not form a complete list when environmental major accidents are the concern, and in any case one of the Article 5 requirements is the identification of

> if necessary, other dangerous substances whose presence could have an effect on the potential hazard presented by the industrial activity.

Thus this table provides the opportunity to consider whether any other substances should be mentioned. In respect of environmental major accidents the EC has prepared a "Black List" of 129 chemicals and this can be consulted [3]. It is recommended that the presence and quantity of any Black List chemical be noted.

Once again the decision can then be made as to whether the substances should be analysed further. There are no guidance quantities for Black List chemicals and the assessment must be made on the basis of the credibility of an environmental major accident, and the proximity of environmental targets - see Section C.

Does this information include all quantities of dangerous substances in any group of installations belonging to the manufacturer which are within 500 metres of each other?

Does this information include all quantities of dangerous substances in any group of installations belonging to the manufacturer where the distance is not sufficient to avoid, in foreseeable circumstances, any aggravation of major accident hazards?

These questions reflect the following requirement within the Seveso Directive, Article 5:

> In the case of industrial activities for which the quantities, by substance, laid down in Annex II or III, as appropriate, are exceeded in a group of installations belonging to the same manufacturer which are less than 500 meters apart, the Member States shall take the necessary steps to ensure that the manufacturer supplies the amount of information required for the notification ... having regard to the fact that the installations are a short distance apart and that any major accident hazards may therefore be aggravated.

This is expanded on in Annexes II and III.

If the answer to either of these two questions is "no", the problem will need to be addressed in Section F, the conclusions. If only part of the site is covered in an assessment, then a "no" answer is inevitable. This need not be a serious problem since interactions between most major accident hazards are often limited, but this will need to be addressed nonetheless.

C: INFORMATION RELATING TO THE INSTALLATION

The purpose of this Section is to collate all information relating to the installation and its locality which is needed to present the safety assessment.

It is provided in three parts:

C1: LOCAL INFORMATION

This information includes the location of the surrounding population and environmental targets, the off-site emergency plans and the information provided to local residents concerning the industrial activity and its major hazard potential.

C2: SITE INFORMATION

This information includes the layout on-site, the details of the activity, and the measures taken to prevent, control and mitigate incidents, including the on-site emergency plan.

C3: INSTALLATION HISTORY

This information relates to accidents, near misses, reliability problems and management failures which have been experienced.

No specific form is used to collate the results of Section C.

C1: LOCAL INFORMATION FORM

The purpose of this form is to collect all the information which is relevant to the safety of the activity which refers not to the site itself, but to its surroundings. This breaks into three areas: factors relevant to potential major accidents, the off-site emergency plan and the information which is required to be provided to the public.

Factors Relevant to Major Accidents

Taking the first area, within the Seveso Directive, Article 5 this covers:

Geographical location of the installations and predominant meteorological conditions and sources of danger arising from the location of the site

Is a geographical map of the location attached?

In what respects is information missing?

A map is necessary to show where the installation is located and its relationship to local features. It is also a convenient way of presenting large amounts of information. The following questions are based on the HSE's CIMAH guidance. The map should show:

- residential areas
- premises where evacuation would prove difficult, such as schools, hospitals and prisons;
- industrial premises;
- other hazardous installations;
- transport features, for example major roads, railways, ports and airports;
- recreational areas;
- geological features and vulnerable features of the environment, for example reservoirs, aquifers, rivers, lakes, marine environments, agricultural land, sites of special scientific interest, other scarce or intermediate habitats;
- features of the man-made environment such as buildings of special historical or

architectural interest, ancient monuments, sites of archaeological importance and conservation areas;

- use of land or water in the vicinity of the industrial activity and also the location of the people who may be affected in the event of a major accident.

Many of the sources of information for this will relate to specific Hungarian conditions. The particular aspects of environmental targets are enlarged on in Section E2, dealing with the identification of potential major accidents. The table there provides a useful checklist.

The map should be to scale and up-to-date, and cover the area around the site as well as the site itself. The distance to which the map should extend will depend on the nature of the hazard. Some information about the hazard radii is given on Form E3 It should be remembered that in addition to identifying key features at risk from the installation, the map should also clearly indicate any external features which may impinge on the safety of the site such as nearby industry or transport systems.

Predominant meteorological conditions:

Ideally this information should show a wind rose, and also give a breakdown of weather stability category and wind speed. The routine availability of this information in Hungary is unknown. Further work on this would be useful.

Off-site Emergency Plan

Is there an off-site emergency plan for the installation?

Name and address of person responsible for maintaining the plan:

Brief description of the plan:

Article 7 of the Seveso Directive states, among other things:

> The Member States shall set up or appoint the competent authority or authorities who, account being taken of the responsibility of the manufacturer, are responsible for ... ensuring that an emergency plan is drawn up for action outside the establishment in respect of whom (sic) industrial activity notification has been given.

When potential major accidents are considered, the details of the plan will be useful in establishing whether an adequate response is planned. Therefore a brief survey of what accidents are covered in the plan and the outline response should be provided.

Specify the areas in which the emergency plan appears to be deficient:

In particular, in the light of HSE guidance [2], the following should be set out in the emergency plan:

- the types of harm to people or the environment to be taken into account;
- organisations involved including key personnel and responsibilities and liaison arrangements between them;
- communication links, including telephones, radios and standby methods;
- special equipment including fire-fighting materials, damage control and repair items;
- technical information such as chemical and physical characteristics and dangers of the substances and plant;
- information about the site including likely locations of dangerous substances, personnel and emergency control rooms;
- evacuation arrangements;
- contacts and arrangements for obtaining further advice and assistance, for example, meteorological information, transport, temporary food and accommodation, first aid and hospital services, water and agricultural authorities;
- arrangements for dealing with the press and other media interests;
- longer term clean-up.

More detailed guidance on the practical aspects of off-site emergency planning is given in [6].

Is the plan up-to-date?

Clearly it is important that the emergency plan should reflect the hazards which the activity currently gives rise to and that it takes account of the latest state of technical knowledge.

Information to the Public

Is information supplied to the public?

Article 8 of the Seveso Directive states:

> Member States shall ensure that information on safety measures and on the correct behaviour to adopt in the case of an accident is supplied in an appropriate manner, and without their having to request it, to persons liable to be affected by a major accident originating in a notified industrial activity ... The information shall be repeated and updated at appropriate intervals. It shall also be made publicly available.
>
> Such information shall contain that laid down in Annex VII.

How, and to whom is it supplied?

Typical distribution means would include display in public buildings and local workplaces, and by post to all local residents, local authorities and to managers of schools, hospitals, prisons, workplaces and so on.

The further questions asked on the form set out what the Directive requires, as specified on Annex VII. Example guidance on possible contents of this information are provided in the HSE guidance on CIMAH ([2], guidance on Schedule 8).

C2: SITE INFORMATION FORM

This section collects together the necessary information concerning the industrial activity on the site itself. This is where the process itself is described, and the safety features for the prevention, control and mitigation of incidents identified. Information about the on-site emergency plan is also collected.

Within the Seveso Directive itself, the information required under Article 5 includes:

> Maximum number of persons working on the site of the establishment
>
> General description of the technological process
>
> A description of the sections of the establishment which are important from the safety point of view
>
> The arrangements made to ensure that the technical means necessary for the safe operation of plant and to deal with any malfunctions that arise are available at all times
>
> Emergency plans, including safety equipment, alarm systems and resources available for use inside the establishments in dealing with a major accident
>
> The names of the person and his deputies or the qualified body responsible for safety and authorised to set the emergency plans in motion and to alert the competent authorities

Site and Process Description

Is a site plan attached?

In what respects is information missing?

The scale plan of the site should show:

- both in location and quantity, the main contributors to the total inventory of the dangerous substances;
- other quantities of dangerous substances, such as amounts in pipework;

- significant centres of on-site employment which may be at risk;
- features of the site which may impinge on the safety of the installation or escalate a major hazard, for instance loading and unloading areas have a relatively high risk;
- mitigatory features such as water catchment and treatment works.

Maximum number of persons on site:

Number of: *permanent employees:*
contractors:
temporary staff:
visitors:

This should include employees, visitors, including delivery staff, clients, and contractors. Account should be taken of the number of people who may be present at shift changeover times and of employees such as sales staff and drivers who may only be present intermittently. Exact numbers are not required.

Describe the industrial activity:

The description, which should enable a clear understanding of the activity to be achieved, will be very dependent on the complexity and novelty of the activity. It is normally useful for the description to include:

- plant diagram showing significant features concerning the potential for a major accident and its prevention and control. It should show storage facilities, process vessels, significant connections, safety features and instrumentation;
- process flow mass balances;
- references to standard industry guidance where appropriate (for example guidance exists in the UK on dealing with LPG [7] and chlorine [8]);
- conditions under which substances are normally held, including physical state, pressure and temperature at various stages of storage and process;
- details of designed maximum working capacities, temperatures and pressures;
- main safety parameters and how they are controlled;
- measures taken to prevent accidents - mainly relating to the management of the

design, construction, operation, inspection and maintenance and security, where this information is not provided in Section D:

- measures taken to control incidents - this is the designed-in means of intervention, including safety relief valves, standby support, redundancy in provision of services, safety hardware (for example dump tanks, cooling sprays, venting to scrubbing systems or flare stacks) manual or automatic shut-down procedures;

- measures taken to mitigate the effects of accidents - including safety refuges for personnel, water curtains, foam blankets, bunding, water treatment plants, emergency services.

Some information concerning the properties of dangerous substances may more conveniently be provided on Form E1.

Main items of safety critical equipment, their location and arrangements for ensuring their availability:

This list should follow from the description given previously and will provide a focus for examining the safety management. It is likely to be developed iteratively with the hazard identification. The list should also, where relevant, describe the measures taken to ensure they are available at all times.

On-site Emergency Plan

Is there an on-site emergency plan?

Brief description of emergency plan:

Specify the areas in which the emergency plan appears to be deficient:

Features to be attended to in the on-site emergency plan include:

- the types of accident to people or the environment to be taken into account;

- means of identifying the emergency;

- alerting essential persons both on and off the site;

- the roles of key personnel;

- access for emergency services;
- the provision of appropriate supplies of adequate fire-fighting media;
- the remote siting of emergency control points;
- the movement to a safe place of non-essential site personnel;
- the control of fire-water run off where the environment may be at risk;
- key personnel and responsibilities, including the person responsible for safety on the site and the names of the people authorised to set the plans in action;
- communication links, including telephones, radios and standby methods;
- special equipment including fire-fighting materials, damage control and repair items;
- technical information such as chemical and physical characteristics and dangers of the substances and plant;
- evacuation arrangements;
- arrangements for dealing with the press and other media interests;
- longer term clean-up.

Name of the person(s) and their deputies authorised to activate the plan and alert the competent authority:

This should be included as an important part of the safety management arrangements, though the information may be repeated in Section D if this section is supplied.

Is the plan up-to-date?

Are affected people, including contractors and visitors, informed of its provisions?

Is the plan tested?

(Note this is not a requirement of the Seveso Directive, but might become so in the future.)

All these questions are relevant to the effectiveness of the emergency plans.

Are the off- and on-site emergency plans consistent?

Clearly it is important that this should be the case.

C3: INSTALLATION HISTORY FORM

This material is required neither by the Seveso Directive nor CIMAH, but provides useful information relating to the reliability of systems, the frequency and causes of incidents and the quality of the safety management. It may also provide information about the site's environmental liabilities, though this not the main purpose.

The information required here is set out on a simple one-page form. For this reason, rather than apply the full document control to each form, a special header sheet, C3/H, is supplied to collate all the installation history forms. This combines all the C3 forms into one document.

Overview of Installation History Search

This part of the C3/H form is provided to allow the analyst to describe the search which has been undertaken to list the plant incidents. The remaining data items are filled in for each C3 form filled in. The information can be collected from records of maintenance, logbooks, reports of incidents, and so on, and can also be gained from interviews with plant staff. It is often possible to form a good picture of plant history from a number of interviews.

Source:

Date information collected:

This information shows how the information was collected (with appropriate reference to C3/H) and will be valuable in establishing its credibility, and for cross checking if necessary.

Does documentation exist?

Again this useful for checking purposes. Incident reports and the like should be referenced.

Date or period of incident:

For isolated incidents or accidents, the appropriate data should be given. An attempt should also be made to identify the period over which experience has been gained of similar incidents. This is essential in estimating the frequency of events.

Description of incident:

This should give a basic description of the incident sufficient to enable the reader to understand what has happened and its significance.

Cause of incident:

If this can be identified.

Type and category of incident:

Incidents can be categorised in various ways - suggested categories are:

- plant failures (reliability problems)
- structural failures
- corrosion failures
- operator errors
- management failures
- fires
- explosions
- losses of containment
- pollution
- personal injury/death

Potential safety implications (on- and off-site):

Potential environmental implications:

These two pieces of information are important to establish past near misses which could have escalated into major accidents.

Action taken:

This not only provides information about the likelihood of the incident happening again but also about whether the management is learning from past experience.

D: INFORMATION RELATING TO THE MANAGEMENT SYSTEM

The purpose of this chapter is to determine the quality and completeness of the management of safety at the plant. Risks are normally estimated assuming a good standard of safety management. Without this the risk posed by the plant can be much higher. Therefore the information collected here can in principle feed through into estimates of the likelihood of major accidents.

This information is not required by the Seveso Directive at present, though some mandatory items more relevant to safety management have been included in other sections. This allows Section D (and Section E3) to be ignored if compliance with the Directive is all that is required. However, it is expected that more focus will be given to this in future for the reasons mentioned, and it is incorporated at present into CIMAH regulations and is expanded on in the CIMAH Regulations and guidance.

Accordingly, this Section is broken into three parts. The first part, D1, covers the staffing arrangements to the extent that they are relevant to safety. The next part, D2. deals with the control systems which need to be in place for the safe management of the plant. These include the engineering control systems, the operational control systems and the material control systems. The third part, D3, deals with the training requirements. This structure mirrors that in the CIMAH regulations, though the details of each section differ in detail.

Information Relating to Staffing

This section of the OSD must demonstrate that there are adequate organisational arrangements for managing safety. This includes the proper definition of line management responsibilities, as well as responsibilities for initiating emergency plans, and the provision of backup to these functions.

Prcvide an organisation chart for the management of the industrial activity:

The chart should show how responsibility for the safety of the operation is accepted in a chain stretching back up to the senior management of the manufacturer, off-site if appropriate. The chart should be drawn up in terms of job titles or posts. However, the name of the person currently occupying each post should be shown. The chart should show the safety technical support available to each person in the management chain, again including off-site support. Form D1 should be completed for each relevant post shown on the organisation chart, including those associated with providing technical services.

Again since D1 is a simple one-page form a special header sheet, D1/H, has been provided for compilation purposes.

What are the arrangements for activating on-site emergency plans?

If this is not shown in the above information a full description should be given here, including Form D1 for the relevant persons. This is likely to expand on the basic arrangements described in Section C2.

What are the arrangements for activating off-site emergency plans.

If this is not shown in the above information a full description should be given here, including form D1 for the relevant persons.

Information relating to control systems

Provide a summary of the control systems used to achieve engineering control, operational control and control of materials, highlighting their inadequacies:

The audit contained on Form D2 should be completed and a summary presented here.

The audit questionnaire which has been compiled in this area should be capable of being completed within a day or two, so as to provide an overview of the quality of safety management applied to the activity. However it is not complete. Full, thorough safety audits are considerably more extensive that the questionnaire presented here, but such an audit would be much broader than required for the present purpose. It is likely that some training and experience will be required to complete the audit effectively.

When the questionnaire has been completed, an audit report should be written up in a way which summarises the findings of the audit, recording in particular those areas which are weak. This is the main output of the audit and is what should be presented above. It represents the specific information that can be used to assess the risk presented by the plant in the light of the safety management regime.

Information relating to training

Provide a summary of the arrangements (and their inadequacies) which are in place to ensure all staff receive appropriate training for the safety aspects of their jobs:

Again an audit questionnaire is provided (Form D3) and when this has been completed, a summary should be provided for inclusion here. It should outline the main features of the training system and the main weaknesses shown up by the audit.

D1: STAFF INFORMATION FORM

Form D1 should be completed for each relevant post shown on the organisation chart, including those associated with providing technical services. If more appropriate, particularly for services outside the line management chain, the form can be completed for an organisation. Because it is a single page form it does not have its own supplementary information and revision history tables. Instead a special header form D1/H is provided for this purpose.

The form should also be completed in respect of those persons with responsibility for initiating on-site emergency plans, and for informing local authorities in the event of an off-site emergency, if this information has not been previously given.

Job title:

Name of current job-holder:

Reports to (job title):

As in the organisation chart given previously.

Deputising arrangements:

The arrangements for appointing competent substitutes during periods of absence should be described.

Safety responsibilities:

This should include all safety-related responsibilities of the post, but focus particularly on those which are relevant to the prevention, control and mitigation of major accidents. If the job-holder has responsibilities for initiating emergency plans, or for off-site communications, this should also be described.

Safety-related decision-making:

The nature of the decisions to be made should be stated, and a comment inserted on the time constraints, and how these are met, including the case of deputisation.

Qualifications and training:

This includes all formal qualifications and training which are required to carry out the safety-related functions of the post.

Experience:

This should cover all the practical experience (also known as on-the-job training) which is required to carry out the safety-related functions of the post.

D2: CONTROL SYSTEMS AUDIT FORM

An audit questionnaire has been compiled to deal with the three main areas of the safety management system.

The first is engineering control with the objective:

- to ensure that safety is considered at all stages of design modification and installation and that any engineering controls are provided to ensure that safety devices are suitably maintained and managed.

This addresses the requirement to consider safety at identified stages of the design and installation process. Consideration should be given to quality assurance of the design process and the provision and maintenance of engineered controls to minimise hazards.

It is important to establish how management ensure that adequate design and engineering controls exist to control the following activities safely:
- Routine and breakdown maintenance.
- Plant or process modifications, and changes to procedures
- Design, construction and commissioning of new plant.
- Work carried out by contractors.
- Setting and maintenance of safety mechanisms.

The second area is operations and emergencies with the objective:

- to ensure that all safety related work and operations carried out by personnel are regulated to minimise the occurrence of unplanned events.

This addresses the need for written operational procedures and determines who is responsible for producing, reviewing and updating each procedure. Assessment is also made of what measures are taken to ensure that uncontrolled copies or out-dated procedures are taken out of circulation and destroyed.

The procedures to be covered are not only those designed to prevent major or "life threatening" events, but also those events which could result in significant financial penalties, due to the loss or reduction of output, faults leading to sub-standard products, etc. The detail of the implementation arrangements will be covered.

The third, and final control area is control of material with the objective:

- to ensure that all material which is stored or moved around is safely controlled by responsible and authorised persons.

This addresses control of material and the arrangements which have been implemented to ensure safety. The duties of persons responsible for handling, storage and movement will be considered together with methods of monitoring the safety performance of these functions.

This will also address security since there is a need to prevent unauthorised persons having access to hazardous materials or the plant in which they are processed.

No detailed guidance is given on the audit form. Advice on carrying out safety audits is beyond the scope of this methodology, but enough is provided in the questions to help someone with good knowledge of safety practice to provide a picture of the completeness and, particularly, the effectiveness of the system sufficient for the purposes here. However, some experience and/or training would be useful in making best use of the form.

D3: TRAINING AUDIT FORM

The objective here is:

- to ensure that all staff with safety related responsibilities receive adequate training and that records of all training are maintained.

Thus an audit questionnaire has been devised which addresses the methods by which appropriate training is received before assuming safety duties. Methods used to identify the training needs of staff and the effectiveness of the training are covered. Updating and maintaining records is discussed and persons who control and supervise the training arrangements identified. Training requirements will vary with the individual post but evidence of a management policy to establish and satisfy those requirements should be sought.

The extent to which staff who are responsible for safety have been formally trained in safety management should be established. The training could have been conducted either by qualified in-house personnel, or a suitable outside agency.

Again similar comments apply to the completion of the audit form as in the case of the control systems. The reason for separate audits is to mirror HSE recommendations for describing safety management provisions [2].

E: INFORMATION RELATING TO POTENTIAL MAJOR ACCIDENTS

The purpose of this chapter is to provide details of the potential major accidents which may arise from the industrial activity and to show how they are controlled.

Article 5 of the Seveso Directive requires the following to be included in the notification to be sent to the competent authority:

> The sources of hazard and the conditions under which a major accident could occur, together with a description of the preventative measures planned
>
> Any information necessary to the competent authorities to enable them to prepare emergency plans for use outside the establishment
>
> Maximum number of persons working on the site of the establishment and particularly of those exposed to the hazard

This is the area where there are the greatest differences in the implementation of the Seveso Directive. In the UK the guidance on the CIMAH Regulations mentions the use of estimates of likelihood as well as consequence and this introduces the idea of a risk assessment, though not necessarily *quantified* risk assessment (QRA). In the Netherlands QRA is mandatory, whilst in Germany no measure of likelihood at all is required.

The approach taken in the OSD is close to the UK approach in that some estimate of likelihood is required. However, quantification of risk will be recommended only for those hazards which are most severe. Otherwise qualitative or semi-quantitative approaches will be recommended.

Section E is structured in the following way. First Form E is used to collect data on the assessment methods used. Then a series of forms is used to collect details of the hazards:

- information relating to the substance - Form E1;
- hazards identified as arising from the substance and those which are potential major accidents - Form E2;
- for each potential major accident identified as being associated with the substance, a detailed assessment on Form E3 - quantitative if required.

Originally a separate independent document was drawn up for each dangerous substance, incorporating all of the forms. However this turned out to be unnecessarily complicated and the approach currently recommended is to compile a single set of E1, E2 and E3 forms.

This arrangement is capable of dealing with concerns other than major accidents, for example relating to the management of worker safety, thought this is not the main purpose of the OSD.

Each of forms E1-3 is described within its own section. We conclude this section of the guidance with Form E, the assessment methods form.

Assessment Methods Form

The purpose of this form is to collect together information on all the assessment methods used.

Overview of Hazard Assessment

This will give an overview of the nature and level of detail of the assessment. It will also demonstrate that consistent methods are being used.

Methods List

This table is used to list the methods used in the assessment, particularly on Form E3, but also in other areas such as hazard identification (E2).

The method should be entered on the table, together with a code to indicate the stage of the assessment at which it is used. The following code is suggested:

HID - hazard identification
LIK - likelihood, or frequency
CON- consequence
RSK - risk calculations

Following this the nature of the method is inserted - hand calculation, structured meeting, computer software - and in the final column further remarks are added. This may include references to the method, an indication of why it was chosen, and so on.

Categorisation scheme: likelihood

Categorisation scheme: harm to man

Categorisation scheme: harm to the environment

The way in which these categorisation schemes should be developed is fully described in the guidance on Form E3 where they are used. They are recorded on this form since they are general across the whole of the assessment. (It is also an option to use such a scheme on Form E1.)

E1: SUBSTANCE INFORMATION FORM

The purpose of this section is to supply the information which enables substances to be identified and their hazardous properties recorded. One of these forms should be completed for each substance identified in Section B as requiring study.

The information required by the Seveso Directive (Article 5 and Annex V) is:

- Chemical name
- Empirical formula
- Composition of the substance
- Detection and determination methods available to the installation
- Methods and precautions laid down by the manufacturer in connection with handling, storage and fire
- Emergency measures laid down by the manufacturer in the event of accidental dispersion
- Methods available to the manufacturer for rendering the substance harmless
- Brief indication of hazards
    - Immediate hazards for man
    - Delayed hazards for man:
    - Immediate hazards for the environment:
    - Delayed hazards for the environment:
- Chemical and/or physical behaviour under normal conditions of use during the process
- Forms in which the substances may occur or into which they may be transformed in case of abnormal conditions which can be foreseen

Much of the information requested on this form may be supplied in the site descriptive material. C2. If so it need not be repeated here.

Identification, Composition and Handling of the Substance

Substance identity:

Provide the chemical name. CAS number, name according to the IUFAC nomenclature, and other names. Also enter the empirical formula. Although all the above information is requested by the Seveso Directive, the purpose is unique identification of the dangerous substance.

Degree of purity of the substance:

Enter the degree of purity and main impurities in the table. What is required here is information about diluents or impurities which might have a significant effect on the hazards the substance causes. It is not necessary to list the minor components of mixtures being processed where these do not have a significant effect on the potential hazard. For this purpose it is convenient to consider substances which can react with the dangerous substance using data such as that in [32]

Detection and determination methods available to the installation:

Description of the methods used or references to the scientific literature.

Methods and precautions laid down by the manufacturer in connection with handling, storage and fire:

Emergency measures laid down by the manufacturer in the event of accidental dispersion:

Methods available to render the substance harmless:

These Seveso Directive requirements are likely to have been described already in connection with the on-site emergency plan. Presumably it is for this reason that the HSE guidance [2] does not mention these requirements explicitly. Any relevant information not previously mentioned should be supplied: if it has been given previously an appropriate reference should be provided.

Brief Indication of Hazards

Immediate hazards for man:

Delayed hazards for man:

Immediate hazards for the environment:

Delayed hazards for the environment:

Information about the hazards which may be created by the dangerous substance should include a consideration of the substance in its normal state as well as any changes brought about by potentially hazardous events including combustion or contact with water. The route of the harm to people should be described (for example skin contact, inhalation, or ingestion for toxic substances and flame contact, thermal radiation, blast or flying debris for flammable or explosive substances). The dose-response relationship should be given where known, citing standard published references where appropriate. Indirect routes such as risk to health by contamination of foodstuffs or drinking water supplies should also be addressed.

In considering environmental hazards it is necessary to consider the relevant properties of the dangerous substance in terms of the environmental targets identified in C1. A completely general approach for each substance would not be useful. The routes to the target should be identified and the effect on it. The relevant properties would include persistence in aqueous or terrestrial environments.

Behaviour of the Substance

Chemical and/or physical behaviour under normal conditions of use during the process:

Forms in which the substances may occur or into which they may be transformed in case of abnormal conditions which can be foreseen:

Again these Seveso Directive requirements are likely to have been described already in connection with the plant description. (And again the HSE guidance [2] does not mention these requirements explicitly.) Any relevant information not previously mentioned should be supplied; and if it has been, it should be referenced.

E2: IDENTIFICATION OF HAZARDS FORM

The output of this section is a list of the hazards arising from the industrial activity. It will include the cause of the hazards and will also investigate the potential consequences if the hazard is realised, including potential major accidents. If a hazard is identified as having the potential to lead to a major accident it is analysed further using the accident assessment form, Form E3. The opportunity to identify hazards for each dangerous substance separately is available, but experience shows this is probably not the most effective way of proceeding.

In general a hazard identification technique will reveal many hazards, not all of which have the potential to cause a major accident. Thus the output of this exercise may also be useful in other contexts, such as providing an assessment of the risk to workers. (Such as an assessment is now required in the UK following implementation of the Management of Safety at Work Regulations which were required as a result of recent EC Directives not related to the Seveso Directive [10].)

Hazard Listing

It is recommended that a high-level HAZOP (or HAZOP I) technique is used to identify hazards. This differs from the usual HAZOP II technique [9] in that it considers the plant at a less detailed level, and without examination of the detailed process parameters. A HAZOP study is undertaken by a multi-disciplinary team, chosen for their specialist knowledge of the process, the installation and its potential hazards. It is a simple, structured procedure used for the identification of plant hazard and operability problems through examination of either flow-sheets, flow diagrams, plant layouts or operating instructions.

The team typically numbers six people. As well as the chairman, who is skilled in the technique, but independent of the installation, and possibly a secretary who records the HAZOP session, it may contain a designer, an operator, a maintenance engineer, a safety expert, or an environmental expert, depending on the purpose and scope of the study. The composition may change during the session.

Systematic questioning of the plant and processes is performed by applying a list of keywords to each plant item, sub-system or system as appropriate. The key words might include items from the following table:

Toxic release, Fire, Explosion, Corrosion / erosion Maintenance, Effluents, Ventilation, Loss of services, Impact (vehicle, aircraft, missile) Escalation, Sabotage, Communications	Equipment failure (vessels, pipes, valves, protection systems, control systems), Operator error (itemise tasks), External hazards (earthquake, subsidence) Extreme weather (lightning, storm, wind, flooding)	Structural failure, Dropped loads, Noise, Emergency services, Natural features, Transport (access road, railways, loss of supplies, loss of exports), Pipework, "Other hazards"

It is not recommended that all these keywords be used in every study: selections should be made to reflect the particular concerns at the site and activity. In particular, the chairman and secretary should familiarise themselves with the environmental targets around the plant (see Appendix) in order to be able to raise possible issues which might otherwise be neglected during the session due to lack of familiarity of the remainder of the team with environmental hazards if no environmental specialist is present.

These keywords are then used as prompts to the team to identify possible causes of the keyword hazard. The information provided in C2 describing the process will also be useful in identifying hazards.

For each keyword, the team identifies any event which might cause the hazard it implies. The causes are entered on the table, and the possible mechanisms for prevention, control and mitigation are identified, and entered in the safeguards column. Emergency plans - on- or off-site would not normally be included here. The consequences of the hazards if the safeguards fail are then entered in a descriptive manner.

A remarks column is not included, though this would be useful to allow the team to enter any comments or items for further action. This is normally a very important part of a HAZOP report, but may be only of marginal interest for the main purposes of the OSD. If necessary remarks can be appended to the form.

The hazard identification may be augmented by information derived from the history of the plant (Form C3) or that of other plants. Accident databases may also be useful in identifying the potential major accidents which might result from the activity (see [33] for example).

The format of the identification of hazards table is very close to standard HAZOP worksheets; it will be acceptable to provide HAZOP worksheets if they contain the required information. These may be used to itemise any comments or remarks, as noted above. Experience shows that the results inspections and HAZOP sessions can conveniently be summarised in such a tabular form, though the table provided is not large enough to contain all the data.

Finally, whatever method is used for the identification of the hazards, it should be marked up on Form E.

Categorised Risk Assessment

At this stage it is possible, and very useful, for the assessor to carry out a first risk assessment using the categorisation techniques described under Form E3. It is often possible to make a judgemental assessment of the likelihoods and consequences, thought this is aided by experience.

Consequently this is optional at this stage and may also be included in the final risk assessment in the conclusions section, Form F.

Potential Major Accidents

The final column of the table records the judgement of the study team or the assessor as to whether the hazard is a potential major accident. In the Seveso Directive the following definition is given:

> *Major accident* means:
>
> - an occurrence such as a major emission, fire or explosion resulting from uncontrolled developments in the course of an industrial activity, leading to a serious danger to man, immediate or delayed, inside or outside the establishment, and/or to the environment, and involving one or more dangerous substances

It should be noted that uncontrolled developments may arise not only from failures on the site but also due to threats from off-site, such as aircraft crashes, or flooding.

Serious danger to people means a risk of death, physical injury or harm to health. The effect may be immediate or delayed. Note that the definition only requires serious danger to be present; it does not require actual harm to people. Major accidents may arise from amounts of dangerous substances much less than the thresholds set in Annexes II and III, and accidents giving rise to indirect potential for harm such as through contamination of a drinking water or food supply. Thus the decision as to whether a hazard can cause a major accident must take account of the local and site information provided in Section C.

A major accident will also have taken place if there has been serious danger to the environment. The Appendix provides guidance on the measures of harm which have been suggested as appropriate in the UK for use under CIMAH [3].

It can be seen that guidance on environmental major accidents is much more extensive than those that harm man. This because of the much greater range of targets and effects. The development of environmental risk assessment is still in its infancy - that is why the information is contained in the Appendix - and it is very much up to the judgement of the analyst as to whether a hazard should be classified as a potential major accident - whether human or environmental. The reasons underlying the judgement should be recorded.

E3: POTENTIAL ACCIDENT ASSESSMENT FORM

The purpose of this form is to provide the necessary information concerning those hazards which have been previously identified as having the potential to lead to a major accident.

This form is completed for all such hazards in the previous section. The form is split into four parts: description of the accident; estimates of likelihood; estimates of consequence; and evaluation.

The descriptive section provides the further necessary detail to understand the accident, including its possible escalation routes. This description will enable the correct methods to be identified for quantification of likelihood and consequences if this is desired. Aids are provided for classifying t' accident into one of several categories, though these are unlikely to be exhaustive, particularly for environmental accidents.

The likelihood section sets out a number of techniques for estimating the chance that the incident arises. These range from categorised judgements, the use of generic and site-specific data and, if necessary, synthetic techniques such as fault trees. The guidance provides only an overview, especially for the more complex techniques. Further detail can be found in the references mentioned at the appropriate points.

The consequence section is required for two reasons. One is to provide necessary information for the development of on- and off-site emergency plans. The other is to feed into the risk evaluation along with the likelihood information. In the same way as for likelihood, consequences can be estimated at differing levels of detail, ranging from assignment into very loosely defined categories, to detailed calculations using computers. Consequence assessment is the least generic part of risk assessment: modelling the consequence is very dependent on the type of accident. Many physical processes may need to be modelled. Description of the many processes and the ways they can be estimated are beyond the scope of this guidance. Some references are provided, but in any case it is very important that these methods are not simply used in an unthinking way. If detailed consequence estimates are to be made, this should be done by an experienced chemical engineer or safety analyst who is aware not only of the methods available, but also of their limitations and boundaries of validity.

Having said this it is also important to think about the purpose of the consequence estimates. For emergency planning, the plans tend not to be dependent on very accurate estimates of hazard ranges; what is much more important is to understand the nature of the hazard and the approximate extent of the effects. For risk assessment, it is recognised that the major source of uncertainty is not usually the consequence calculations, but the estimates of likelihood. This is particularly likely to be the case in Hungary where it is not known if generic failure rates used in the UK and elsewhere have any relevance to local conditions.

Description

Description of the accident:

Number of persons exposed to the accident:

This description should enlarge on the information provided in E2, giving all detail necessary to assess the risk from the accident. It should describe the different escalation routes where appropriate (see below). The request to supply the number of persons affected by the accident is derives from a requirement in the Seveso Directive.

Classification of the accident:

Figure 1 is a diagram of the various ways in which major accidents can arise. It is not complete, but it does provide an overview of the main features. For accidents leading to harm to man the situation is relatively well understood. For harm to the environment the diagram is vaguer and undoubtedly less complete. This reflects our less developed understanding of major environmental accidents. The diagram shows the potential for almost all events leading to serious danger to man as possibly harming the environment, though this depends on the circumstances of the plant. Some of the environmental accidents of particular concern are marked explicitly. An indication is also given on the diagram that operational or fugitive emissions can lead to a major environmental accident over a period, though this lies outside the scope of this methodology. The diagram can be used to provide descriptive material to answer the question, or alternatively a copy of the diagram can be attached with the accident route highlighted. This might be especially useful if a single hazard may have several escalation routes, or several routes to harm.

Escalation is the process whereby one incident gives rise to another. For example, a fire in an LPG tank farm may give rise to a BLEVE which generates missiles leading to a tank being punctured and a toxic gas being released. This can be dealt with in several ways, but it is implicit in Figure 1 that the approach recommended here is to consider the final release, noting that it is caused by escalation of a previous incident. This emphasises the point that more than one scenario may be considered on one of these forms. In the present example this would be a major toxic release caused, perhaps, by catastrophic containment failure, and also the same magnitude of release caused by missiles from a BLEVE. Equally the events could be treated separately, especially if identified separately at the hazard identification stage. The choice is up to the analyst, and will be mainly based on convenience.

Description of on-site response:

Has the on-site response been specifically designed against this accident?

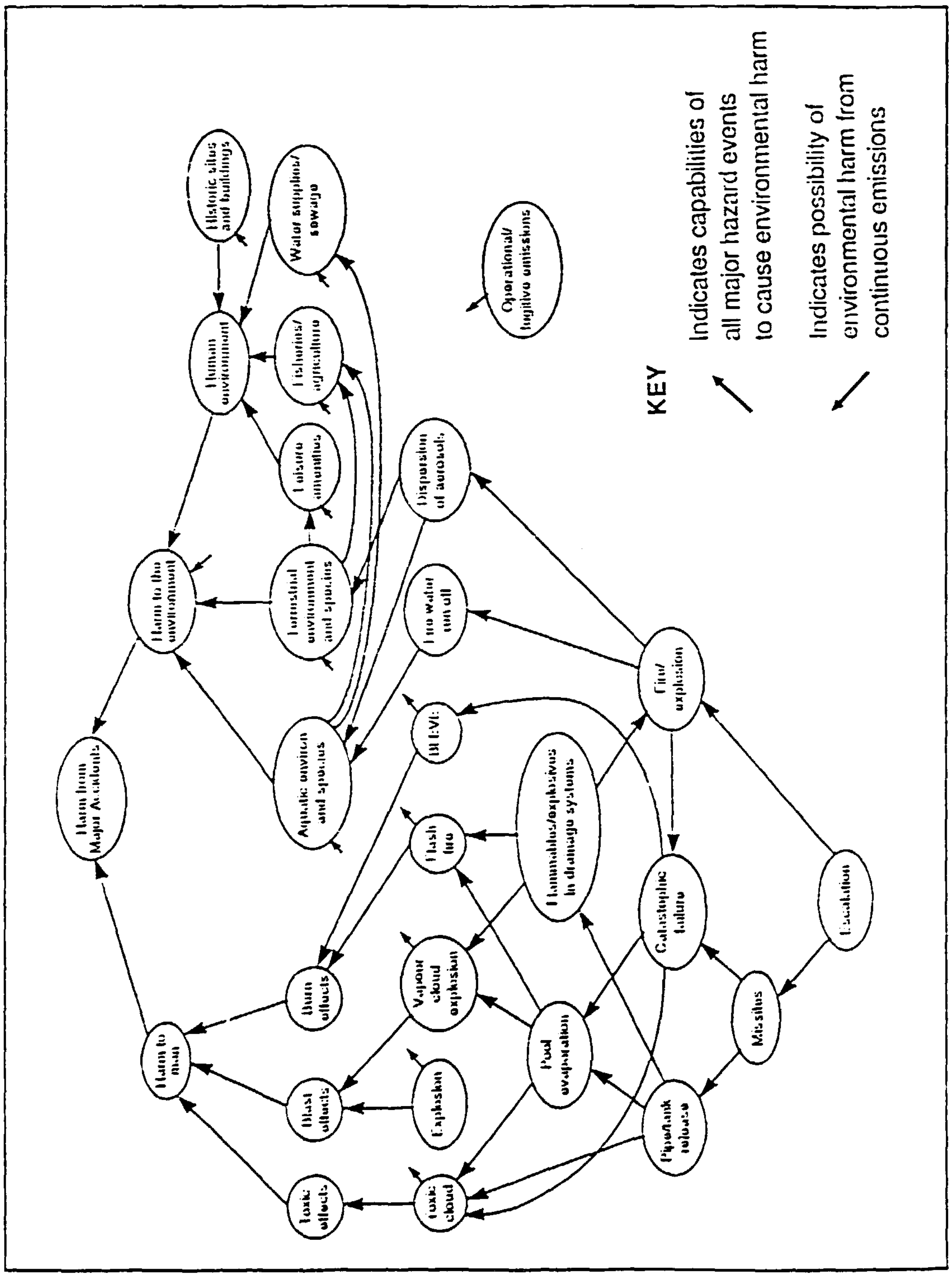

Figure 1 Diagram of Major Accident Processes

Description of off-site response:

Has the off-site response been specifically designed against this accident?

The descriptions should be brief, drawing on the material entered in Section C. Any shortcomings in the arrangements should be noted. These are particularly likely if the plans were not designed against the accident being considered.

Estimates of Likelihood

This can be approached in three ways:

- assignment to likelihood categories based on the judgement of the analyst, or the hazard identification team, taking plant experience into account;
- quantitative estimates based on generic failure rates, simple assessments of the protective systems, plant experience and the quality of the safety management
- quantitative estimates based on synthetic techniques such as fault tree analysis. In this case data will need to be provided for the base events of the fault tree in the same way as for the second method.

These methods go into successive levels of detail, and the final area will be described only in outline. Use of the first two is likely to be adequate for most purposes.

The need to go to a further level of detail is likely to be due to either:

- a demonstration from the total risk evaluation stage in Section F that the accident is dominating the risk and therefore warrants more detailed study; or
- a view that there is a serious inadequacy in the higher level method; this might be a feeling that the gross assessment misses some feature or that detailed assessment of a highly engineered protection system is necessary to identify single failure modes.

Thus it is recommended that the form is not completed in detail for every accident, but that instead a simple assessment is made initially. The evaluation in Secti[illegible] begun and further analysis carried out only as appropriate.

Categorised likelihood assessment

A scheme is prepared based on qualitative descriptions of the likelihood or frequency of the accident. A possible scheme, based on bands of approximately 30 in frequency is shown in the following table:

Cat	Description	Approximate frequency	Approximate recurrence time	Descriptive recurrence time
A	Often happens	10 per year	-	many times a year
B	Has happened	.3 per year	3 years	every few years
C	Might happen	10^{-2} per year	100 years	many times in a thousand years
D	Unlikely to happen	$3x10^{-4}$ per year	3000 years	every few thousand years
E	Extremely unlikely	10^{-5} per year	100.000 years	many times in a million years
F	"Incredible"	$3x10^{-7}$ per year	3.000.000 years	every few million years

Obviously it is unlikely that a major accident would be in classes A or B, but these are included to help the analyst think about frequencies. These are also the levels at which there will actually be plant experience, and this can be used in the assessment in the way described below.

The first point to make is that the difference between each class is quite large - a factor of 30. This means that a high degree of reliability is required to move an event from one class to the a lower one. This would typically be done

- to assess the frequency of an accident for which there was plant experience of a precursor (or "near miss") using an estimate of the likelihood of the precursor actually leading to the accident;

- to assess the frequency with which an initiating event which is normally prevented from causing a major accident by a protective system will escalate due to failure of the system.

Experience in the nuclear industry shows that a well engineered system will at best have a failure probability of 0.001 per demand, that is, two categories on the scale set out on the table. Less well engineered systems, such as operator interventions, should be assigned an improvement of one category only, if at all.

Thus the following items of information can be used to assign accidents to categories:

- overall view of the analysts or hazard identification team about the likelihood of the accident;

- existence of related precursors or near misses recorded in Form C3;

- overall view of the effectiveness of the protection systems, based again on plant experience, degree and quality of engineering and so on;

- overall view of the quality of safety management based on information in Section D, especially D2; areas particularly relevant to the accident should be identified.

Obviously a common categorisation scheme should be used for the assessment, and this should be recorded on the assessment methods form, Form E.

Category assigned:

Reasons/data:

The accident should be assigned to one of the categories in the scheme using the processes and information indicated above. The reasons and data for making the decision should be recorded so that the judgements are understandable to the reader.

Generic frequency assessment

In its own risk assessments of major hazards sites, the HSE uses a number of generic frequencies for losses of containment. They are based on recent UK experience for well designed and managed plant. These frequencies are not used without critical appraisal: they are adjusted to reflect local conditions, especially as regards the safety management, and are also adjusted in the light of guidance from specialist inspectors on particular topics. Thus the HSE recognises the difficulties involved in estimating accident frequencies to the same level of accuracy as accident consequences, and also recognises that quite crude methods are the best that can be done, provided always that expert advice on particular topics is sought.

This emphasises the point that risk assessment cannot be regarded as a mechanical exercise with a single set of methods and data guaranteeing the most appropriate result.

The generic frequencies used by the HSE for different losses of containment are set out in the following table:

Failure Mode	Frequency	Comment
Vessel, catastrophic	4×10^{-6} per year	Depending on the material, there may be a flashing release or evaporation following capture in a bund.
Vessel, 50 mm diameter hole	5×10^{-6} per year	Holes are assumed to occur roughly 50% in the gas space and 50% in the liquid space.
Vessel, 25 mm diameter hole	5×10^{-6} per year	As above
Vessel, 13 mm diameter hole	1×10^{-5} per year	As above
Vessel, 6 mm diameter hole	4×10^{-5} per year	As above
Pipe (less than 50 mm diameter), guillotine break	1×10^{-6} per metre per year	All pipe-work figures are assumed to include valve body failures.
Pipe (greater than 50 mm diameter), guillotine break	5×10^{-7} per metre per year	HSE recommends that above 150 mm diameter a topic specialist should be consulted.
Pipe, 25 mm diameter hole	5×10^{-6} per metre per year	
Pipe, 4 mm diameter hole	1×10^{-5} per metre per year	
Flanged joint, ejection of 1 gasket segment between bolts	4×10^{-6} per joint per year	This is the average figure of those used by the HSE.
Pump body failure	3×10^{-5} per year	Assumed to be equivalent to downstream guillotine failure

Flexible transfer hose, guillotine failure	$3x10^{-6}$ per loading cycle	
Cantilevered transfer arms, guillotine failure	$7.5x10^{-6}$ per loading cycle	

In assessing the releases due to these failures, account should be taken of any back-flow which may occur.

The HSE also provide release durations for simple protective systems, assuming success, and also failure probabilities. These are set out in the following table.

Protective System	Release Duration (mins)	Failure Probability	Comments
Manual Valve	20	small	Emergency closure by operator taking suitable precautions
Remotely operated shut-off valve	5	0.03	This would also include a pump which could prevent the release
Automatic shut-off valve	1	0.01	For a gas detection system the duration may be longer, and the failure probability greater
Excess flow valve or non-return valve	1	0.013	Could be an order of magnitude more unreliable if checked infrequently

These figures provide a basis for estimating the frequency of losses of containment based on counts of the number of vessels, pumps, flanges and transfer points, and also the length of pipe-work. They include all failures, including operator errors.

Clearly there is considerable uncertainty associated with them and they need to be altered to reflect local conditions, including materials used, pressure and temperature, scope for operator intervention, reliability history, and in particular the quality of management. According to [11] the range of accident frequencies experienced by well and badly managed plants can differ from the average by up to a factor of 5 either way. The HSE [11] recommend adjustments to account for this of up to half an order of magnitude. However, in situations where the management of safety is particularly poor compared with average UK standards the frequencies may be increased by considerably more than this. However, this is a highly judgemental area, and has to be left to the discretion of the analyst and his specialist advisors.

Basic generic frequency used:

Reasons/data:

Effect of protection systems:

Reasons/data:

Adjustment factor:

Reasons/data for adjustment:

These questions allow the analysts to input a basic failure frequency, modify this to allow for the success of protection systems so that a release time is obtained, and finally to adjust the frequency to account for the safety management or other relevant factors. The reasons and information used in all these judgements should be described.

In many cases this may best be done in a separate attachment. In this case the complete assessment, including the use of adjustment factors may be best kept together.

Detailed systems analysis

If the assessment based on generic failure rates is thought to be insufficient for some reason, a more detailed systems analysis and quantification can be carried out. This would allow the detailed causes of the accident to be identified and quantified. The following is a brief description of what can be done. A full account is beyond the scope of this guidance and the references should be consulted (and the need for training considered).

The main technique for this is fault tree analysis [12]. This is a method which allows a logical model to be drawn up which shows all the ways in which the accident can come about. In some cases, preliminaries to carrying out the fault tree analysis might be failure modes and effects analysis (FMEA [13]), or perhaps a detailed HAZOP II [9]. Both these techniques allow a detailed analysis of a system or procedure with a view to identifying how it can go wrong.

The fault tree will contain a number of base events the frequency of which will need to be quantified. The methods for doing this depend on their nature. Reliability failures, such as pumps or electronic systems can be obtained from databases, or databases. Human failures can be assessed using appropriate techniques which account for the nature of the task to be performed. Two popular alternatives are HEART [14] or ASEP [15]. It is also important to check the fault tree for common cause failures. This is where the integrity of redundant systems is compromised due to some common cause affecting both lines of protection. Assessment of common cause failures can be carried out using appropriate methods [16].

When failure data has been identified for each base event, the fault tree can be quantified. This is normally done using specialist software. This allows the detailed estimate of accident frequency to be made.

Methods used should be recorded on Form E. assessment methods.

Estimates of Consequences

It has been previously noted that calculating the consequences of major accident is a complicated matter. This is because different models are needed for each process shown on Figure 1. In many cases more than one model may be required. for example to cope with different conditions. or because different degrees of accuracy are required. It is also the case that consequence calculations are quite uncertain, though this is often retained within limits by dimensional considerations.

The models used are often embodied in software. However, the provision or development of software is beyond the scope of this methodology. In any case it is possible to become over-confident in the results of computer calculations, and in carrying out risk assessments it is important to retain a level of specialist input to the modelling to check that the models are not being used outside their domain of validity.

Thus in this guidance it is possible only to give an overview of the topic. No attempt is made to compile a handbook of models - this has in any case been done elsewhere [11, 17, 19]. The approach taken is first to suggest a categorisation method similar to that proposed for likelihoods. This is supported by a qualitative description of the consequences of the main processes in Figure 1. This is followed by a overview of the methods available, based principally on HSE guidance on this [11]. It should be possible using the references cited to make hand calculations of the effects of interest, and also to see which areas would be better treated with computerised models.

This will allow the analyst to make very approximate assessments of consequences and to find ways of making better assessments, whether these involve hand calculations or software.

Categorised consequence assessment

The following tables describe a suggested set of categories which could be used for major accidents. There are separate tables for harm to man and to the environment. It should not be assumed that the categories are intended to be comparable between man and the environment. To the greatest extent possible the factor of 30 between consequences has been retained in a similar way to that for likelihoods.

Harm to Man

Cat	Description
A	No effect
B	Worker injury
C	Worker death
D	Widespread worker deaths
D*	Deaths off-site
E	Multiple off-site deaths

The categories D and D* have been so labelled since it is not apparent that one is more serious than the other - indeed in many cases they will represent roughly equivalent accidents, but simply as a convenience to distinguish between on- and off-site effects.

For environmental accidents it is possible to introduce some idea of the cost of the accident. This would include the cost of the clean-up following the incident, and also the value of those environmental targets which could not be restored. This is clearly controversial but is not unreasonable at this level of detail, and to help in thinking about the consequences of environmental accidents. The figures inserted are probably more appropriate to Western conditions; they could be adapted for Hungary by setting the Category B consequence at an average annual salary and using the x30 multiplying factor.

Harm to the Environment

Cat	Description	"Cost"
A	No effect	-
B	Nuisance	$30k
C	Minor environmental incident	$1M
D	Major environmental incident	$30M
E	Environmental catastrophe	$1000M

Again it should be emphasised that these categories are only suggestions and other categories might be more suitable for a particular site. This would be particularly true for environmental accidents where the categories could account for different levels of harm to the main environmental targets. Whatever categorisation is used, it should be included on the assessment methods Form E.

A series of questions to help in estimating major accident consequences is provided in the Appendix. It is based on Figure 1. It was developed particularly in the context of environmental risk, but in principle applies to all major hazards. For accidents to man the picture is relatively well understood; for accidents to the environment it is based on experience gained from risk assessments carried out at a number of sites and from real incidents.

What follows here is a very brief summary of those parts of Figure 1 which lead to harm to man, together with an order of magnitude indication of the hazard range.

Fire

Fires can include BLEVEs, flash fires from the release of flammable gases, jet and pool fires, particularly where these have the potential to lead to escalation, and fires involving buildings, such as warehouses. The consequences of fires depend on the ignition point and probability and in the case of dispersing flammable clouds, the weather conditions. Basic guidance on hazard ranges is:

- BLEVES - hundreds of meters
- flash fires - extent of cloud, hundreds of metres to fall to lower flammable limit
- jet fires - tens of metres
- pool fires - twice pool size
- storage fires - many tens of metres

Explosion

Explosions can include vapour cloud explosions following the release of flammable material, the missile generation effects of BLEVEs and detonations of solid phase explosive materials. For humans inside buildings, the main hazard arises from collapse of the building. Thus for large explosions the hazard range can extend to about a kilometre. Missile generation hazards exist over a range of hundreds of metres. For people outdoors, the hazard range is only a few hundred metres.

Toxic Release to Air

Toxic releases to air can occur as a result of release of toxic material and subsequent advection in the atmosphere or release in a fire or explosion event. The hazard range for humans can extend several kilometres downwind of the plant with a plume width of several hundred metres. Material released in fires can be spread even further afield.

Detailed consequence assessment

This section of the guidance sets out a brief overview of the methods available for carrying out an assessment of the consequences of a major accident in more detail where this is required. This is done only for harm to man where the position is relatively well established. For accidents to the environment specialist techniques are needed, and there is as yet no consensus as to the best set of methods to use.

The following discussion is heavily based on the methods recommended for use by the HSE in connection with CIMAH safety reports [11], and is therefore very appropriate for use in the OSD context. Once again the discussion is based around Figure 1.

The purpose of these models is to determine a hazard region for the accident. There are two basic ways to characterise the hazardous properties of an accident. One is to develop a probit, that is a relationship between some sort of dose and the fraction of the population likely to be affected, and then examine the dose levels as a function of position. The other is to simply say that at some dose level 100% of the population is affected in some way. The area bounded by the corresponding dose level is the hazard region. This second approach has been adopted by the HSE for land-use planning and other purposes. However if the dose chosen is sub-lethal for most of the population, the calculated risk will be higher than the average risk of death and a more realistic assessment may be appropriate. However, this approach is considered adequate for the purposes of the OSD. Indeed it will be useful to characterise the hazard region as simply as possible so as to facilitate risk calculations using tools such as spreadsheets.

In any event the end output of the detailed analysis should be an estimate of the number of casualties and the degree of environmental damage from each incident, as a function of wind direction and other weather conditions if appropriate.

Release Rates

[11] gives an overview of the methods available for calculation of release rates for liquids, flashing liquids and gases. These methods are suitable for hand calculation and are based on information in Lees [19] and the Chemical Engineers Handbook [20]. Alternative specialist publications such as the Chemical Industries Association guidance on chlorine [18] may be useful.

Pool Evaporation

If pools of volatile material form following a release the rate at which the material can form a cloud and disperse is determined by the evaporation rate from the pool. This calculation needs to be carried out using computer programmes. One such is the code GASP [21].

BLEVEs

Simple correlations are available [11] to calculate the size and duration of the fireball produced by a BLEVE, and hence the thermal radiation flux at a target some distance away. The hazard region is a simple circle centred on the fireball.

Pool Fires and Jet Fires

These fires are mainly of interest for their ability to cause escalation of incidents by impinging on other parts of the plant. Methods for calculating their thermal fluxes are referenced in [11].

Flash Fires

A cloud of flammable gas can drift some distance before being ignited. The hazard range of the resulting fire is determined by this drifting distance as there are few casualties outside the extent of the cloud. This requires dispersion modelling which is discussed below. However correlations for butane and propane have been given in [22] based on dispersion models. The hazard region can be estimated from downwind and crosswind distances to the lower flammable limit. It is also important to consider ignition probabilities.

Ignition Probabilities

A major source of uncertainty for flammable or explosive materials stems from lack of knowledge of the ignition probabilities, and how they vary as a function of distance from the release. A typical approach is given in the Canvey study [25] which indicates that this is highly dependent on the judgement of the analysts.

Vapour Cloud Explosions (and other explosions)

Reference [11] provides a method for estimating blast overpressure from the explosion of larger clouds of flammable gas and also refers to a paper by Considine and Grint [22] which expands on this. The hazard radius is circular about the site of the cloud, though it should be remembered that the cloud may have drifted from its release position before ignition - see comment on ignition probabilities again.

Thermal Radiation Effects

Reference [11] provides dose information based on work in [23]. This is used to provide simple look up charts for the range at which 50% lethality is attained for fireballs. The same information can also be used for other types of fires if required, though, as stated, the effects of flash fires can be estimated from knowledge of the cloud size.

Blast Effects

As previously mentioned the main blast effects on people come from the collapse of buildings. 50% lethality occurs at an overpressure of 34 kPa [22] in these cases, but at overpressures as much as an order of magnitude higher for people outside affected by the blast wave alone. Overpressure models based on explosive yield are available [11].

Gas Dispersion

Reference [11] provides models for the dispersion of instantaneous and continuous releases of a passive gas. It also points to the need for special techniques for dense gas clouds. For hand calculations the Britter-McQuaid workbook [27] can be used. Alternatively [11] recommends use of the codes DENZ and CRUNCH which are now superseded by the code DRIFT [24]. However, this is also an area where the individual properties of the gases - for example how they interact with water - can be extremely important, and again the need for specialist advice is indicated. The same is true for special properties of the location such as terrain and obstacles.

Toxicity

This is a difficult area in general. Reference [11] provides a number of references to HSE reports setting out the approach used, in particular for chlorine, acrylonitrile, hydrogen fluoride and ammonia, and, in the future, hydrogen sulphide. The general HSE approach is discussed in [26]. Further information on toxicities are given in [34].

Evaluation

This stage to some extent pre-judges the total evaluation in the next. The main purpose here is to summarise the risk from the accident at the appropriate level of detail and to question whether any obvious improvements are required to the plant in the areas of prevention, control, mitigation, or emergency response.

For categorised assessments the risk is determined by the frequency-consequence category pair previously worked out (or possibly pairs if several scenarios are being considered at once).

For the detailed assessments more calculation is required to calculate levels of individual and societal risk if this is thought to be needed. This area lies outside the scope of the OSD and so only a few brief comments will be made to point the way if required. In any case the information could alternatively be provided in Section F.

Individual risk represents the chance with which an individual identified person will suffer a given level of harm, usually death. This is generally calculated as a function of position around the plant in terms of the annual probability of being killed. One representation is thus in terms of individual risk contours.

Societal risk is the chance of accidents of different consequences occurring. These are generally represented by an fN line. This is a plot on a log-log scale in which the horizontal axis is number of people killed (or other measure of severity) and the vertical axis is the frequency. The fN line at point N is the frequency of accidents killing N people or more and is thus cumulative. In order to calculate this it is necessary to have estimates of the population distribution around the plant.

Computer codes can be used to calculate the individual risk contours and fN lines due to accidents on a site. However these are not likely to be available for use in preparing an OSD and it is recommended that spreadsheets be used to store and aggregate the relevant data. This is relatively straightforward if the hazard region is parameterised in a simple way.

Likelihood:

Safety consequence:

Environmental consequence:

These three questions should summarise briefly what has been found in the previous parts of the assessment.

Overall risk:

This should provide estimates of individual and societal risk as appropriate if these calculations have been carried out.

Opportunities for prevention:

Opportunities for control:

Opportunities for mitigation:

The ways in which the accident could be prevented should be systematically thought through, and following this the same can be done for means of controlling the accident if it occurs, and mitigating its effects.

Actions proposed or to be taken:

Finally the analyst should set out what actions are recommended on the plant in the light of the assessment if this is appropriate.

F: CONCLUSIONS FORM

The nature of the conclusions of the OSD will depend on its purpose, as set out in Section A. For example, the function of a safety justification is to answer the question of whether the activity is adequately safe and to set out the proposed action if it is not. A safety assessment might simply analyse the hazards and perhaps *suggest* a list of improvements. However, the discussion that follows looks at this mainly from the point of view of a safety case or justification. Note though, that it is not the function of this methodology to set out what would constitute a tolerable level of risk in Hungary; in the UK and other EC countries this has been the subject of considerable debate. Therefore very little guidance has been given in this area.

It was remarked at the start that the Seveso Directive is concerned with the prevention of major accidents. This is enlarged on in the UK where the objectives of the safety report are [2]:

- to identify the nature and scale of the use of dangerous substances at the activity; and

- to identify the type, relative likelihood and consequences of major accidents that might occur; and

- to give an account of the arrangements for safe operation of the activity, for control of serious deviations which might lead to a major accident, and for emergency procedures at the site.

Following on from this the HSE say:

> It is for the manufacturer to satisfy HSE that all major accident hazards have been identified and the proposed, or actual precautions are as described, and are appropriate to the hazards.

Thus the material presented here should particularly address this last issue, assuming the material presented previously satisfies the main objectives. If not, the fact should be noted.

A risk-based approach depends on showing the hazards have been identified and are appropriately controlled. The level of control is best illustrated by examining the likelihood and consequences of major accidents in parallel. This can be done either at the level of a categorised assessment, or in a quantitative way as outlined in the previous section. Once again we shall not go into much detail concerning the quantitative evaluation since this lies outside the scope of the OSD for the purposes of satisfying the present Seveso Directive, or future versions.

Summary table of potential major accidents

This table is used to collate the results of the previous accident analyses. There are columns to identify and describe the accident briefly. The results of the assessment in terms of likelihood and consequence are marked. The final column is for use following the main assessment: it can be used to record the priority attached to the accident, whether any follow-up action is planned or suggested to reduce its risk and so on.

Categorised Risk Evaluation

The potential major accidents considered in the previous section can be plotted on a so-called risk matrix. This is a simple structure where the consequence categories are plotted horizontally and the likelihood categories vertically. Thus an accident which is high likelihood and consequence will tend to appear towards the top right corner of the matrix. Such accidents are the ones which deserve the most attention.

The categories could be set up in such a way that the lines of equal risk run at 45 degrees through the matrix. For example, if risk is considered to be defined by frequency times consequence and equal jumps are chosen for each category (eg the factor of 30 used in Form E3 for frequency and environmental consequence), this would be the case. However it needs to be emphasised that this would be a value judgement and that it may be more appropriate, for example, for the higher consequence accidents to be given higher weight.

It was noted previously that the categorised risk assessment could be carried out following the initial hazard identification.

At any rate the risk matrix provides a way to clearly identify those accidents which need to be given more detailed consideration. This can take the form of a quantitative analysis on Form E3 or it may take the form of proposals for reducing the risk - either by reducing its likelihood, its consequence or both. Finally it may be that the risk is considered tolerable, that it is adequately controlled, in which case a statement to this effect should be made.

Likelihood Category	A					
	B					
	C					
	D					
	E					
	F					
		A	B	C	D	E
	Consequence category					

Risk matrix for harm to man

Risk matrix for harm to the environment

These two matrices should be filled in for all the accident analysed in E3 using the categorisation method. The accidents can be marked using a code, or perhaps by a brief phrase indicating their nature if this is possible. It needs to be done for both harm to man and to the environment if different categorisations are required for these two effects.

Quantitative Risk Evaluation

If, for the risk-dominant hazards, details of individual and societal risk have been calculated and are available in the form of individual risk contours and fN lines for example, these presentations can be aggregated to show the risk for the activity as a whole. It might be more appropriate to present this evaluation as an attachment to Form F.

This presentation would permit an evaluation of the risks on an absolute basis. The debate on acceptable or tolerable levels of risk has been long-lasting and is still unresolved. The question of what levels are appropriate for Hungarian conditions has not been addressed within the development of this methodology and should be studied elsewhere.

In the UK the debate has been crystallised most recently within the report of the Advisory Committee on Dangerous Substances [28] and on the Tolerability of Risk from Nuclear Power Stations [29]. The topic is not pursued further here.

This part of the form should be used to set out the quantitative risk levels and the way they are viewed.

Overall Risk Evaluation

The main purpose of assessing risks is to identify and prioritise weaknesses in the systems which can then be addressed so as to reduce risk. This issue should already have been addressed for each accident in the detailed analysis form. Thus at this stage it is necessary to ask, using the information provided by the qualitative and quantitative assessments what more can be done to reduce risk, and whether the resulting risks are acceptable, tolerable, as low as reasonably achievable or whatever criterion is appropriate.

Is the information supplied above complete?

This question should be used to note any major omissions in the information supplied and or in the scope of the case. For example, if it does not cover all the dangerous substances in installations operated by the manufacturer within 500 metres (see Section B), this fact should be explained and justified. Obviously the completeness of the information will have a major effect on the utility of the safety assessment.

Are the measures which have been identified to prevent, control, mitigate and protect against major accidents adequate?

If the answer is yes, then a justification of this needs to be provided which is appropriate for

Hungarian conditions.

Set out the measures which are suggested/planned such that major accidents will be further prevented, controlled, mitigated and protected against:

This part of the form is used to set out the action plan which is necessary to ensure adequate safety for the industrial activity. This plan might simply be that proposed in the light of an internal assessment, or it might be a plan of improvements committed to by the manufacturer in order to be to allowed to continue operation by a regulator, or in order to meet his internal targets for safety and environmental performance.

APPENDIX: GUIDANCE ON ENVIRONMENTAL ISSUES

This Appendix contains two sections. The first covers the information which is useful at the hazard identification stage (Form E2). It classifies potential environmental targets and the measures of harm which could be used to estimate risk. The second provides advice, in the form of a series of questions, to assist the analyst in estimating consequences in filling in Form E3. This takes account of the fact that the field of risk assessment for major hazards is less well developed for harm to the environment than for harm to man.

Hazard Identification

For the purposes of this guidance, targets at potential risk from a major accident have been categorised within five groups: terrestrial sites and habitats; aquatic environment; particular species; historic sites and buildings; and environmental impacts upon man. Suggested indicators or measures of harm are given against the different categories, based principally upon those suggested in the UK in the context of the CIMAH Regulations [3]. To a large extent, the standards proposed draw upon the features and standards defined in existing conservation legislation in the UK and will need to be adopted to Hungary. Where appropriate, further guidance on the basis of the categorisation is given.

Terrestrial sites and habitats

Environmental Category	Measure or Indicator of Harm
Nature Sites of National or International Importance	Loss of nature conservation value measured in terms of: i) Permanent or long term damage to a defined fraction (>10%) or area (>0.5 hectares) of the site; ii) Permanent or long term damage to a defined fraction (>10%) of a particular habitat at the site; iii) Loss of or damage to defined fraction (>10%) of a particular species at the site.
Nature Sites of Local Importance	Permanent or long term damage to a defined area (>5 hectares or less if falling into scarce habitat category below) of the site.

Scarce Habitat	Permanent or long term damage to a defined area (>2 hectares).
Intermediate Habitat	Permanent or long term damage to a defined area (>5 hectares).
Wider Environment	Permanent or long term damage (including contamination leading to prevention of agricultural use and denial of public access as well as ecological damage) to a defined area (>10 hectares).

Definitions within each category will depend on conditions within each country. In the UK systems exist for identifying these targets, and the equivalent will need to be present or be set up in Hungary.

Aquatic environment

Environmental Category	Measure or Indicator of Harm
Rivers	Effect upon a specified length (>10 km) as judged in terms of: i) Lowering of water quality against a defined classification relating to biological and chemical characteristics for a defined period (>1 year); ii) Long term damage to the habitat overall.
Lakes	Effect upon a specified area (>1 hectare) as judged in terms of: i) Lowering of water quality against a defined classification relating to biological and chemical characteristics for a defined period (>1 year); ii) Long term damage to the habitat overall.
Aquifers/Groundwaters	Contamination (or other) effect which would: i) Preclude use for public domestic or agricultural water supply; ii) Cause significant adverse impact on surface waters, as judged by the criteria defined above for rivers and lakes.

Particular species

Environmental Category	Measure or Indicator of Harm
Plant or animal species in general	The loss (or inability to reproduce) of a significant proportion ($>1\%$) of the national population, by direct effects (fire or acute poisoning), or indirect effects (destruction of habitat or effects on the food chain).
Nationally rare or endangered species	The loss (or inability to reproduce) of a significant proportion of the national population where the quantitative threshold representing a "significant" proportion may be judged to be lower than 1% on the basis of the national rarity of the species.
Internationally rare or endangered species	The loss (or inability to reproduce) of a significant proportion of the population where the quantitative threshold representing a "significant" proportion may be judged to be lower than 1% of the national population by reference to its significance in respect of the total international population lost and the wider international rarity of the species.

Again comments regarding local national conditions apply.

Historic sites and buildings

Environmental Category	Measure or Indicator of Harm
Ancient Monuments	Damage resulting in loss of archaeological importance, against defined national criteria.
Areas of Archaeological Importance	Damage resulting in loss of archaeological importance, against defined national criteria.
Historic Buildings	Damage resulting in loss of historic or architectural importance, against defined national criteria.

Again comments regarding local national systems apply.

Environmental impacts upon man

Environmental Category	Measure or Indicator of Harm
Recreational Facilities	Damage resulting in loss of aesthetic, cultural or public amenity value.
Public Access	Long term (>1 year) contamination resulting in the need for restriction of public access to a defined area (>10 hectares) of the wider environment.
Agricultural Areas	Long term (>1 year) contamination which prevents the growing of crops or grazing of animals on a defined area (>10 hectares) of the wider environment.
Fisheries	Long term contamination which prevents fishing or aquiculture over a significant area.
Water Sources	Interruption of supply to a defined number (>10,000) of consumers due to: i) Contamination which renders water unfit for human consumption; ii) Damage to Water Treatment Works or distribution system.
Sewerage Facilities	Damage leading to: i) risk to public health due to contamination of a water source; ii) wider hazard to public health through flooding.

Consequence Assessment

This series of questions for identifying the environmental effects of potential major accidents is based on experience gained from risk assessments carried out at a number of sites and from real incidents. It is not exhaustive and the assessment team should always be alert to the possibility of identifying risks specific to a given situation which are not covered by previous experience.

Fire

a Direct Effects

i) What is the limit of the hazard range of the direct effects of fire?
ii) Which human and environmental targets fall within this hazard range?
iii) What is the likely extent of damage to any human and environmental targets identified as being at risk?

b Fire Spread

i) What is potential extension to the hazard range due to the fire spreading from its source?
ii) Which human and environmental targets fall within this extended hazard range?
iii) What is the likely extent of damage to any human and environmental targets identified as being at risk?

c Fire Water Run-off

i) What toxic materials might contaminate any fire water run-off and at what concentration levels?
ii) How might fire water run-off reach environmental targets?
ii) What, in terms of the aspects noted in the guidance on toxic releases to water below, are the potential consequences to the aquatic environment of any run-off?

Explosion

a Direct Effects

i) What is the limit of the hazard range of the direct blast effects?
ii) Which human and environmental targets fall within this hazard range?
iii) What is the likely extent of damage to any human and environmental targets identified as being at risk?

b Translocated Effects

i) What is the potential for translocation of explosive mixtures, for example through drainage systems, which would extend the range of the explosion hazard?
ii) Which human and environmental targets fall within this extended

explosion hazard range?

iii) What is the likely extent of damage to any human and environmental targets identified as being at risk?

Toxic Release to Air

a Direct Effects

i) What is the hazard range for acute toxic effects? For environmental targets the hazard range is obviously very dependent on the nature of the target as well as that of the toxic material.

ii) What human and environmental targets lie within this hazard range?

iii) What is the likely extent of acute (short term) damage to any human and environmental targets identified as being at risk?

b Indirect Effects on Land

i) Will there be toxic fall-out to land and, if so, over what area will these be at levels likely to cause ecological harm?

ii) What environmental targets lie within this potentially affected area?

iii) Is the toxic fall-out chemically persistent in the longer term (i.e over months or years)?

iv) Will the toxic fall-out be retained (by binding to soil) or be washed rapidly (on the basis of high aqueous solubility) from the contaminated site and dispersed?

v) If persistent, what is the potential for bioaccumulation within the ecosystem and knock-on effects in the food chain, to higher animals more widely in the environment and to man?

vi) Taking into account the ecotoxicity, persistence and bioaccumulation as necessary, what is the likely extent of acute (short term) and chronic (longer term) damage to any environmental targets identified as being at risk?

(Note. The persistence and bioaccumulation of chemicals within the environment are important factors determining the longer term impact of a release. Quantitative indicators of levels of persistence and bioaccumulation which are considered to represent a threat to the aquatic environment have been defined in the context of the implementation [30] of EC legislation [4]. Such quantitative indicators may be of use in determining which chemical releases are likely to be of most concern regarding their potential to cause a major environmental impact.)

c Indirect Effects on the Aquatic Environment

i) Is the water run-off from the site likely to contain harmful concentrations of toxic materials derived from the fall-out?

ii) What, taking into account the aspects addressed under toxic releases to water below, are the potential consequences on the aquatic environment?

Toxic Release to Water

a Surface Waters

i) What is the pathway for surface water run-off in the event of a liquid release?

ii) What is the range within surface waters of any contaminant above its aquatic toxicity limit? It is not possible to give guidance on this without detailed modelling.

iii) What will be the overall effect on water quality in the receiving waters and over what length of river or area of lake?

iv) What specific environmental targets are contained within the potentially affected area?

v) What are the water uses down stream from the point of contamination (domestic water supply, livestock water, irrigation, fishing, leisure and general amenity) which might be affected?

vi) Is the released dangerous substance chemically persistent in the aquatic environment in the longer term (i.e over months or years)?

vii) Will it be retained (by binding to sediment) or be flushed rapidly through the surface water system and be dispersed?

viii) If persistent, what is the potential for bioaccumulation within the ecosystem and knock-on effects in the food chain, to higher animals more widely in the environment and to man?

vi) Taking into account the ecotoxicity and any persistence and bioaccumulation as necessary, what is the likely extent of acute (short term) and chronic (longer term) damage to any environmental targets identified as being at risk?

b Aquifers/Groundwaters

i) What, according to local geology, is the local general vulnerability of groundwaters to contamination? (Note. Work on defining vulnerability is going on in the UK.)

ii) What are the local uses of any groundwater (domestic or livestock water supply, irrigation) which might be affected by contamination?

20135
(3 of 4)

SRD

SRD. Wigshaw Lane. Culcheth. Cheshire. WA3 4NE.

OUTLINE SAFETY DOCUMENT FOR MAJOR HAZARD PLANT IN HUNGARY:

ANNEX 2

DATA ENTRY FORMS

Prepared by SRD
February 1993

AEA TECHNOLOGY

OUTLINE SAFETY DOCUMENT			A
IDENTIFICATION			
INDUSTRIAL ACTiVITY:			1
NUMBER:	ISSUE:	DATE:	

Prepared by:	Signature:	Date:

Contents

Index	Title	Issue	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT	A
IDENTIFICATION	
INDUSTRIAL ACT'VITY:	2

NUMBER:	ISSUE:	DATE:

Industrial activity:

Manufacturer:

Site:

Purpose of assessment:

Responsible Person:

OUTLINE SAFETY DOCUMENT	B
APPLICABILITY	
INDUSTRIAL ACTIVITY:	1

NUMBER:	ISSUE:	DATE:

Prepared by:	Signature:	Date:

Attachment List

No	Title	ID	Issue	No Pages	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT	B
APPLICABILITY	
INDUSTRIAL ACTIVITY:	2

NUMBER:	ISSUE:	DATE:

Is the industrial activity carried out in an industrial installation referred to in Annex I and involving one or more of the substances listed in Annex III?

Does the industrial activity involve storage of one or more of the substances and preparations in Annex II?

Substances listed in Annex II and Annex III

Number	Chemical Name	Stage of Activity	Quantity	Further Study?

OUTLINE SAFETY DOCUMENT			B
APPLICABILITY			
INDUSTRIAL ACTIVITY:			3
NUMBER:	ISSUE:	DATE:	

Other dangerous substances

Number	Chemical Name	Stage of Activity	Quantity	Further Study?

Does this information include all quantities of dangerous substances in any group of installations belonging to the manufacturer which are within 500 metres of each other?

Does this information include all quantities of dangerous substances in any group of installations belonging to the manufacturer where the distance is not sufficient to avoid, in foreseeable circumstances, any aggravation of major accident hazards?

OUTLINE SAFETY DOCUMENT			C1
LOCAL INFORMATION			
INDUSTRIAL ACTIVITY:			1
NUMBER:	ISSUE:	DATE:	

Prepared by:	Signature:	Date:

Attachment List

No	Title	ID	Issue	No Pages	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT			C1
LOCAL INFORMATION			
INDUSTRIAL ACTIVITY:			2
NUMBER:	ISSUE:	DATE:	

Factors Relevant to Major Accidents

Is a geographical map of the location attached?

In what respect is information missing?

Predominant meteorological conditions

Wind direction	Probability

Stability category	Wind speed	Probability

OUTLINE SAFETY DOCUMENT			C1
LOCAL INFORMATION			
INDUSTRIAL ACTIVITY:			3
NUMBER:	ISSUE:	DATE:	

Off-site Emergency Plan

Is there an off-site emergency plan for the installation?

Name and address of person responsible for maintaining the plan:

Brief description of the plan:

Specify the areas in which the emergency plan appears to be deficient:

Is the plan up-to-date?

OUTLINE SAFETY DOCUMENT			C1
LOCAL INFORMATION			
INDUSTRIAL ACTIVITY:			4
NUMBER:	ISSUE:	DATE:	

Information to the Public

Is information supplied to the public?

How, and to whom is it supplied?

Does it:

(a) provide the name of the company and the address of the site?

(b) identify, by position held, the person giving the information?

(c) Confirmation that the activity is subject to legislation implementing the Seveso Directive - not yet relevant in Hungary

(d) explain, in simple terms, the activity undertaken on the site?

(e) name the substances and preparations involved on the site which could give rise to a major accident, with an indication of their principal dangerous characteristics?

(f) provide general information relating to the nature of the major accident hazards, including their potential effects on the population and the environment?

OUTLINE SAFETY DOCUMENT		C1
LOCAL INFORMATION		
INDUSTRIAL ACTIVITY:		5
NUMBER:	ISSUE:	DATE:

(g) provide adequate information on how the population concerned will be warned and kept informed in case of an accident?

(h) provide adequate information on the actions the populations concerned should take, and on the behaviour they should adopt in the event of an accident?

(i) confirm that the company is required to make adequate arrangements on-site, including liaison with the emergency services, to deal with accidents and to minimise their effects?

(j) refer to the off-site emergency plan(s) above?

(l) advise cooperation with any instructions or requests from the emergency services at the time of the accident?

(k) supply details of where further relevant information can be obtained?

OUTLINE SAFETY DOCUMENT			C2
SITE INFORMATION			
INDUSTRIAL ACTIVITY:			1
NUMBER:	ISSUE:	DATE:	

Prepared by:	Signature:	Date:

Attachment List

No	Title	ID	Issue	No Pages	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT			C2
SITE INFORMATION			
INDUSTRIAL ACTIVITY:			2
NUMBER:	ISSUE:	DATE:	

Site and Process Description

Is a site plan attached?

In what respects is information missing?

Maximum number of persons on site:

Number of: permanent employees:

contractors:

temporary staff:

visitors:

Describe the industrial activity:

Main items of safety critical equipment, their location and arrangements for ensuring their availability:

OUTLINE SAFETY DOCUMENT	C2
SITE INFORMATION	
INDUSTRIAL ACTIVITY:	3

NUMBER:	ISSUE:	DATE:

On-site Emergency Plan

Is there an on-site emergency plan?

Brief description of emergency plan:

Specify the areas in which the plan appears to be defective:

Name of the person(s) and their deputies authorised to activate the plan and alert the competent authority:

OUTLINE SAFETY DOCUMENT	C2
SITE INFORMATION	
INDUSTRIAL ACTIVITY:	4

NUMBER:	ISSUE:	DATE:

Is the plan up-to-date?

Are affected people, including contractors and visitors, informed of its provisions?

Is the plan tested?

Are the off- and on-site emergency plans consistent?

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY:			H
NUMBER:	ISSUE:	DATE:	

Prepared by:	Signature:	Date:

List of C3 Forms Attached

No	Incident	Classification	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT	C3
INSTALLATION HISTORY	
INDUSTRIAL ACTIVITY:	H

NUMBER:	ISSUE:	DATE:

Overview of Installation History Search

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY:			1
NUMBER:	ISSUE:	DATE:	
EVENT:			

Source:

Date information collected:

Does documentation exist?

Date or period of incident:

Description of incident:

Cause of incident:

Type and category of incident:

Potential safety implications (on- and off-site):

Potential environmental implications:

Action taken:

OUTLINE SAFETY DOCUMENT			D
MANAGEMENT SYSTEM			
INDUSTRIAL ACTIVITY:			1
NUMBER:	ISSUE:	DATE:	

Prepared by:	Signature:	Date:

Attachment List

No	Title	ID	Issue	No Pages	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT			D
MANAGEMENT SYSTEM			
INDUSTRIAL ACTIVITY:			2
NUMBER:	ISSUE:	DATE:	

Information Relating to Staffing

Provide an organisation chart for the management of the industrial activity:

What are the arrangements for activating on-site emergency plans?

What are the arrangements for activating off-site emergency plans?

OUTLINE SAFETY DOCUMENT	D
MANAGEMENT SYSTEM	
INDUSTRIAL ACTIVITY:	3

NUMBER:	ISSUE:	DATE:

Information Relating to Administrative Control Systems

Provide a summary (based on Form D2) of the adminstrative control systems used to achieve engineering control, operational control and control of materials, highlighting inadequacies:

OUTLINE SAFETY DOCUMENT	D
MANAGEMENT SYSTEM	
INDUSTRIAL ACTIVITY:	4

NUMBER:	ISSUE:	DATE:

Information Relating to Training

Provide a summary (based on Form D3) of the arrangements (and their inadequacies) which are in place to ensure all staff receive appropriate training for the safety aspects of their jobs:

OUTLINE SAFETY DOCUMENT			D1
STAFF INFORMATION HEADER			
INDUSTRIAL ACTIVITY:			H
NUMBER:	ISSUE:	DATE:	

Prepared by:	Signature:	Date:

List of D1 Forms Attached

No	Job Title	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT			D1
STAFF INFORMATION			
INDUSTRIAL ACTIVITY:			1
NUMBER:	ISSUE:	DATE:	
JOB TITLE:			

Name of current job-holder:

Reports to (job title):

Deputising arrangements:

Safety responsibilities:

Safety-related decision-making:

Qualifications and training:

Experience:

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY:			1
NUMBER:	ISSUE:	DATE:	

Prepared by:	Signature:	Date:

Attachment List

No	Title	ID	Issue	No Pages	Comment

Revision History

Date	Issue	Comments

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		2
NUMBER:	ISSUE:	DATE:

Engineering Control

Control of design

Is the design process set up to:

- a Ensure that the technical objectives are achieved?
- b Identify stages of the process where checks are required?
- c Provide a specification for safety requirements?
- d Identify and accommodate commissioning and maintenance requirements?

Is use made during design, commissioning, maintenance and modification of hazard identification and assessment techniques such as:

- a Hazard and operability studies (HAZOP)?
- b Hazard analysis (HAZAN)?
- c Failure Mode and Effects Analysis (FMEA)?
- d Fault trees and event trees?
- e Reliability assessments?
- f Task analysis and installation procedures?

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY:			3
NUMBER:	ISSUE:	DATE:	

What standards, codes etc are used in the design process?

- a Hungarian, other European, US or international standards?
- b Company engineering and design standards?
- c Company codes of practice?
- d Competent authority (regulator) guidance notes?

Do company directives and guidance provide adequate design advice, to help achieve future integrity, such as:

- a The use of approved standards?
- b Mandatory hazard assessments?
- c Safety assessment of design modifications?
- d Approval requirements for completed designs?

Do company directives and guidance define suitable construction or modification requirements, including:

- a Preparation of work schedules and method statements?
- b Testing and inspection during installation?
- c Approval of test results?
- d Safety assessment of modifications during construction?
- e Handover procedure prior to commissioning?
- f Monitoring, recording and reporting requirements?
- g Material certificates and treatment records?
- h Quality assurance requirements?

Control of maintenance, inspection and testing

Are routine maintenance requirements formally identified and schedules produced for each plant item?

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		5
NUMBER:	ISSUE:	DATE:

Is "safety critical" maintenance, inspection and testing identified and are sufficient safeguards employed for:

- a Work with potential to damage plant?
- b Work with potential for personal accident?
- c Work on safety related equipment?

Are written procedures in place for the safe handover and hand-back of plant between the operator and maintenance staff?

Are records kept of maintenance, inspection and testing carried out and are any problems encountered analyzed to:

- a Improve procedures?
- b Identify training requirements?
- c Initiate incident investigations?
- d Identify incomplete maintenance?
- e Record variations to the maintenance procedure?

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	6

NUMBER:	ISSUE:	DATE:

Are arrangements in place to ensure that the programmed completion of routine maintenance is monitored to identify and correct any maintenance, inspection and testing backlog?

Are statutory maintenance requirements recognised and is compliance ensured?

Are Permit-To-Work (PTW) methods/procedures for controlling hazardous work implemented where maintenance and construction work is performed?

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY:			7
NUMBER:	ISSUE:	DATE:	

Is there a procedure by which personnel are made aware of their responsibilities under the hazardous work procedure?

Have all the requirements for specialised safe working procedures been assessed?

Do the hazardous work procedures ensure safe working with regard to:

- a Electrical work and isolation?
- b Hot work?
- d Lockouts and disabling devices?
- e Falling and moving equipment?
- f Use of chemicals?
- g Confined space / Hazardous location working?
- h Roof access?
- i Excavation?
- j Crane maintenance and rail access?
- k Other (identify) ______________________________?

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY:			8
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Are procedures applied to control the use of safety critical tools and equipment such as:

- a Blanks, spades and disabling devices?
- b Scaffolding, harnesses and ladders?
- c Lifting tackle and cranes?
- d Portable electrical tools and machines?
- e Maintenance shielding?

Are acceptance criteria included in maintenance and installation procedures?

Are procedures in place for reporting any abnormalities or deficiencies found during maintenance?

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		9
NUMBER:	ISSUE:	DATE:

Control of modifications

Are safety assessments carried out to look at the effect of modification on the plant and how such modifications affect the as-built design safety?

a Are modifications categorised?

b What assessment methods are employed for modifications?

Does the assessment process include the implementation stage of modifications as well as the operational stage?

Is formal authority and approval required in the procedure before commencement of the proposed work?

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		10
NUMBER:	ISSUE:	DATE:

Is a procedure used to control the handover of modified plant between those responsible for the modifications and those who control/use the modified plant and does it include authorisation and approval of any concessions?

Are drawings, procedures and training programmes updated as part of the modifications procedure?

Is guidance provided for all those involved regarding the use of a modifications procedure?

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		11
NUMBER:	ISSUE:	DATE:

Is there a procedure which ensures that the workforce is informed and kept up to date with progress?

Are quality assurance procedures applied to the design process for:

- a Setting company design standards?
- b Auditing against those standards?
- c Identifying and implementing required corrective actions?

Does the commissioning (of new plant) procedures provide rigorous control including:

- a Approved and witnessed commissioning schedules?
- b Approval of procedures and operating instructions?
- c Approval requirements at identified stages?
- d Safety approval of modifications during commissioning?
- e Monitoring, recording and reporting requirements?
- f Handover procedure prior to operations?
- g Quality Assurance requirements?

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY:			12
NUMBER:	ISSUE:	DATE:	

Are methods used to register and update drawings etc so that:

- a Drawing originals are retained at one central location?
- b Superseded copies are destroyed?
- c There is a current list of persons issued with drawings?
- d Unique numbers are issued and copies are controlled?

Are design safety reviews and engineering reviews held at appropriate points in the design, construction and installation of a new facility or modification?

- a Are checklists used to prevent missing out important safety considerations?
- b Is a range of disciplines involved in the review?

Is the effectiveness of the engineering and design features of the system adequately demonstrated against company safety standards?

- a Are there relevant design policy statements?
- b Are details of all significant changes recorded?
- c Is auditing and feedback incorporated into the system?

Control of Operations and Emergencies

Control of operations

Are company and departmental guidelines used to identify what procedures are required for normal and abnormal operations, and emergencies?

Are the results of hazard analyses, new legislation, incident investigations and monitoring used as an input to identify and modify operating or other procedures?

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	14

NUMBER:	ISSUE:	DATE:

Are there formal safety assessed procedures for all normal plant and equipment operations?
Are documentation systems controlled:

- a Are suitably qualifed and experienced persons selected to develop and improve procedures?
- b Are all procedures and instructions subject to a formal check and review process?
- c Are all documents periodically reviewed?
- d Are all operational procedures registered and subject to controlled issue?
- e Are all copies of superseded procedures withdrawn and destroyed?
- f Are all document changes subject to an adequate modification procedure?

Do the company directives and guidance for operational facilities clearly identify the safety requirements, including:

- a Formal emergency procedures and exercises?
- b Safety approved operational procedures and rules?
- c Approved and acknowledged operating instructions?
- d Formal maintenance schedules and procedures?
- e Safe systems of work which are to be used?
- f Monitoring, recording and reporting requirements?
- g Procedures for accounting/control of hazardous substances?
- h Waste monitoring and discharge requirements?

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		15
NUMBER:	ISSUE:	DATE:

Are safety critical tasks highlighted and do special provisions exist to ensure compliance with the procedures regarding:

- a Manning levels and staff standards?
- b Plant safety limits?
- c Calibrations?
- d Special operating conditions?
- e Emergency routines?
- f Shift handovers?
- g Special equipment?

Are systems in place for the reporting and investigation of any abnormalities, malfunctions, etc?

Are the procedures for the shut down of plant or process in the event of an emergency adequately promulgated and displayed?

Are procedures in place for the inspection and hand-back of plant, after maintenance, by operations staff?

Has each member of staff whose duties include responsibility for emergency command, been assessed for suitability in this role?

Control of emergencies

Are staff aware of written company guidance on what emergency arrangements are required, and the procedures for implementing them?

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CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	17

NUMBER:	ISSUE:	DATE:

Do local arrangements exist for communications with external authorities, the media, and the public, in the event of a major emergency, and do they include control of statements, etc?

Do arrangements exist for the protection of vital records (for example duplication, dispersal, etc)?

Do procedures exist to limit the effects of business interruptions, such as the loss of output due to a fire, on other parts of the organisation and its customers?

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	18

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Are management promptly informed of all significant incidents or emergencies, as part of a formal information procedure?

Do emergency procedures address all accident scenarios required by legislation and those identified in the hazard assessments?

Are all persons attached made aware of their duties and responsibilities in the event of an emergency?

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CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	19

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Are emergency procedures practised and assessed by holding:

a Routine emergency drills?

b Periodic large scale emergency exercises?

Do practices involve all employees and contractor's staff present during the time of the emergency exercise/drill?

Are large scale exercises programmed, which involve emergency and rescue services and all employees and contractors' staff present, to provide a realistic test of the envisaged procedure?

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		20
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Are the results of exercises recorded, analyzed and utilised?

Are minimum manning levels specified for control rooms and other vital manned areas and are they supplemented during busy work periods?

Is specific emergency training provided for:

- a Permanent staff?
- b Contractors?
- c Emergency services?
- d Visitors?

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY:			21
NUMBER:	ISSUE:	DATE:	

Are the emergency procedures reviewed at a suitable frequency?

Is the provision of emergency equipment such as emergency lighting, fire-fighting equipment, breathing apparatus and emergency egress equipment reviewed to ensure adequacy:

- a Periodically on a regular basis?
- b In the event of modifications to plant?
- c With regard to technological advance?
- d Against changes of legislation?
- e As a result of incident investigations or analysis?

Are emergency response teams provided and are they suitably trained to perform their required duties of:

- a Fire fighting?
- b Rescue of personnel?
- c Administering of first aid?
- d The wearing of respiratory protective equipment?

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	22

NUMBER:	ISSUE:	DATE:

Are installed emergency protection devices tested regularly and the results recorded for:

- a Emergency shutdown devices?
- b Deluge systems?
- c Audible and visible alarms?
- d Fire fighting equipment?
- e Escape and rescue equipment?
- f Emergency lighting?
- g Scrubbing/venting systems?
- h Flame arrestors?

Are scrubbing and venting systems used on vessels containing quantities of hazardous materials?

Are such systems:

- a Capable of scrubbing the full vessel capacity?
- b Suitable for the hazardous material in the vessel?

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY:			23
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Is the size and composition of an emergency response team regularly reviewed and are their duties formally identified?

Do the emergency procedures require liaison and notification to external agents and emergency services such as:

- a Local Authorities?
- b Fire Brigade?
- c Ambulance?
- d Police?
- e Ministries?
- f Police?
- g Competent authorities?
- h Other countries?

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	24

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Control of Material

Are Plant/Department arrangements in place for the maintenance of an inventory of all substances which are classified as hazardous or which may become so during a work activity?

Are there requirements for all such substances to be assessed, suitably labelled and catalogued in order to provide procedures and instructions for:

a Safe storage?
b Safe handling?
c Safe use?

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	25
NUMBER: ISSUE: DATE:	

Has the following questioning approach and order been applied to the use of hazardous materials used on site?

a Is the material really needed (can the material be eliminated)?

b Can a less harmful material substitute for it?

c What engineering controls can be put in place to reduce the danger (for example deluge/sprinkler systems)?

d And only as a last resort - what personal protective equipment should be used?

Are there arrangements which ensure that any work which involves the use of hazardous substances is subject to the requirements of the relevant legislation?

Are quality and safety checks performed on all material which is:

a Purchased from an external source?

b Manufactured or produced by operations?

c Likely to deteriorate over a period of time?

OUTLINE SAFETY DOCUMENT CONTROL SYSTEMS AUDIT		D2
INDUSTRIAL ACTIVITY:		26
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Are monitoring arrangements in place which track all materials used and record details of their final disposal route?

Are arrangements in place which ensure that surplus material is returned to a store and disposed of externally if no longer required?

Have suitably authorised persons been identified trained and appointed in writing for the receipt, issue and control of particularly hazardous material?

OUTLINE SAFETY DOCUMENT		D2
CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY:		27
NUMBER:	ISSUE:	DATE:

Is training provided and formal assessment required to ensure that material handling plant and equipment is operated only by qualified staff who have been formally appointed?

Are there implemented schedules which ensure that all material handling plant and equipment whether owned by the company or hired from an external source is subjected to:

a Periodic maintenance and servicing?
b Regular safety examination and testing?
c Pre-use checks by the operator?

Are suitable material handling procedures provided to those concerned in order to ensure that loading, unloading, handling and the storage of material for movements within and outside the Company are carried out correctly to avoid injury and loss?

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY:	28

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Are procedures in place which ensure that any company material which is transported on a public highway has been correctly packaged and labelled according to the relevant legislation?

Is there a procedure on waste material which encourages recycling or careful disposal with regard to the environment?

Has consideration been given to the safety of other storage areas/places of significant hazardous substances belonging to this plant such as:-

- a Separate warehousing?
- b Transit depots?
- c Tank farms?

OUTLINE SAFETY DOCUMENT CONTROL SYSTEMS AUDIT			D2
INDUSTRIAL ACTIVITY:			29
NUMBER:	ISSUE:	DATE:	

Are members of the public prevented from entering the premises?

Are the security arrangements appropriate to the hazards of the activities?

Are there any special security considerations such as:-

a nearby schools or prisons?
b hazardous materials?
c dangerous plant?

Are site boundary fences regularly patrolled, inspected and kept in good condition?

OUTLINE SAFETY DOCUMENT			D3
TRAINING AUDIT			
INDUSTRIAL ACTIVITY:			1
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Prepared by:	Signature:	Date:

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TRAINING AUDIT			
INDUSTRIAL ACTIVITY:			2
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Do managers receive adequate safety training or have access to suitably qualified and experienced safety advisors?

Do managers identify new training requirements:

- a As a result of incident/accident analyses?
- b As a result of audit, survey, and inspection reports?
- c As a result of new or modified processes or equipment?
- d As a result of changes in legislation?
- e As a result of task analyses?

Is management monitoring of safety training requirements and achievements applied at all the line management levels and to all members of the workforce?

OUTLINE SAFETY DOCUMENT	D3
TRAINING AUDIT	
INDUSTRIAL ACTIVITY:	3

NUMBER:	ISSUE:	DATE:

Do the staff and safety advisors' training include:

- a The concept of loss control?
- b Planned inspection techniques?
- c Accident/incident investigation?
- d Safety management monitoring techniques?
- e Occupational health and industrial hygiene?
- f Purchasing and engineering controls?
- g Personal communications?
- h Legislative duties and requirements?
- i Group meetings?
- j Property damage and waste control?
- k Environmental issues relevant to the plant/process?
- l Refresher training?

Are suitable teaching facilities and tutors provided in order to meet all the training requirements?

OUTLINE SAFETY DOCUMENT	D3
TRAINING AUDIT	
INDUSTRIAL ACTIVITY:	4

NUMBER:	ISSUE:	DATE:

What training methods are used:

- a On the job training?
- b Internally organised courses?
- c Formal external training?

Are the requirements for induction and refresher training, identified and programmed?

Are checks made on the training needs of all contractors to ensure that they are met before deployment on the plant?

OUTLINE SAFETY DOCUMENT	D3
TRAINING AUDIT	
INDUSTRIAL ACTIVITY:	5

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Do systems exist for assessment of the effectiveness of training?

Are the training records comprehensive and regularly updated?

Are the training requirements for long term contractor's employees implemented regarding:

- a Emergency training?
- b Safety training?
- c Induction training?

OUTLINE SAFETY DOCUMENT			E
ASSESSMENT METHODS			
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Overview of Hazard Assessment

OUTLINE SAFETY DOCUMENT			E
ASSESSMENT METHODS			
INDUSTRIAL ACTIVITY:			3
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Assessment Methods List

Method	Stage	Nature	Purpose	Additional Information and References

OUTLINE SAFETY DOCUMENT		E
ASSESSMENT METHODS		
INDUSTRIAL ACTIVITY:		4
NUMBER:	ISSUE:	DATE:

Categorisation scheme: likelihood

Cat	Description	Approximate frequency	Approximate recurrence time	Descriptive recurrence time

Categorisation scheme: harm to man

Class	Description

Categorisation scheme: harm to the environment

Class	Description	"Cost"

OUTLINE SAFETY DOCUMENT			E1
SUBSTANCE INFORMATION			
INDUSTRIAL ACTIVITY:			1
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SUBSTANCE:			

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OUTLINE SAFETY DOCUMENT			E1
SUBSTANCE INFORMATION			
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NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			

Identity, Composition and Handling of the Substance

Substance identity:

Degree of purity of the substance:

Main impurities

Impurity	Relative percentage

Detection and determination methods available to the installation:

OUTLINE SAFETY DOCUMENT	E1
SUBSTANCE INFORMATION	
INDUSTRIAL ACTIVITY:	3

NUMBER:	ISSUE:	DATE:
SUBSTANCE:		

Methods and precautions laid down in connection with handling storage and fire:

Emergency measures laid down in the event of accidental dispersion:

Methods available to render the substance harmless:

OUTLINE SAFETY DOCUMENT			E1
SUBSTANCE INFORMATION			
INDUSTRIAL ACTIVITY:			4
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			

Brief Indication of Hazards

Immediate hazards for man:

Delayed hazards for man:

Immediate hazards for the environment:

Delayed hazards for the environment:

OUTLINE SAFETY DOCUMENT	E1
SUBSTANCE INFORMATION	
INDUSTRIAL ACTIVITY:	5

NUMBER:	ISSUE:	DATE:
SUBSTANCE:		

Behaviour of the Substance

Chemical and/or physical behaviour under normal conditions of use:

Forms in which the substances may occur or into which they may be transformed in case of foreseeable abnormal conditions:

OUTLINE SAFETY DOCUMENT			E2
HAZARD IDENTIFICATION			
INDUSTRIAL ACTIVITY:			1
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SUBSTANCE:			

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OUTLINE SAFETY DOCUMENT			E2
HAZARD IDENTIFICATION			
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SUBSTANCE:			

Hazard Listing

Supply the requested information in a suitable format

Hazard	Cause	Safeguards	Consequences	Potential Major Accident?	Reasons

OUTLINE SAFETY DOCUMENT			E2
HAZARD IDENTIFICATION			
INDUSTRIAL ACTIVITY:			3
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			

Categorised Risk Assessment (optional)

Risk matrix for harm to man

Likelihood Category						
	A					
	B					
	C					
	D					
	E					
	F					
		A	B	C	D	E
	Consequence category					

OUTLINE SAFETY DOCUMENT			E2
HAZARD IDENTIFICATION			
INDUSTRIAL ACTIVITY:			4
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			

Risk matrix for harm to the environment

Likelihood Category						
	A					
	B					
	C					
	D					
	E					
	F					
		A	B	C	D	E
	Consequence category					

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY:			1
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			
POTENTIAL MAJOR ACCIDENT:			

Prepared by:	Signature:	Date:

Attachment List

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OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY:			2
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			
POTENTIAL MAJOR ACCIDENT:			

Description

Description of the accident:

Number of persons exposed to the accident:

Classification of the accident:

Description of on-site response:

Has the on-site response been specifically designed against this accident?

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY:			3
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			
POTENTIAL MAJOR ACCIDENT:			

Description of off-site response:

Has the off-site response been specifically designed against this accident?

OUTLINE SAFETY DOCUMENT	E3
POTENTIAL ACCIDENT ASSESSMENT	
INDUSTRIAL ACTIVITY:	4

NUMBER:	ISSUE:	DATE:
SUBSTANCE:		
POTENTIAL MAJOR ACCIDENT:		

Estimates of Likelihood

Categorised likelihood assessment

Category assigned:

Reasons/data:

Generic frequency assessment

Basic generic frequency used:

Reasons/data:

Effect of protection systems:

Reasons/data:

Adjustment factor:

Reasons/data for adjustment:

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY:			5
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			
POTENTIAL MAJOR ACCIDENT:			

Detailed systems analysis

OUTLINE SAFETY DOCUMENT	E3
POTENTIAL ACCIDENT ASSESSMENT	
INDUSTRIAL ACTIVITY:	6

NUMBER:	ISSUE:	DATE:
SUBSTANCE:		
POTENTIAL MAJOR ACCIDENT:		

Estimates of Consequences

Categorised consequence assessment

Category assigned:

Reasons/data:

Detailed consequence assessment

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY:			7
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			
POTENTIAL MAJOR ACCIDENT:			

Evaluation

Likelihood:

Safety consequence:

Environmental consequence:

Overall risk:

OUTLINE SAFETY DOCUMENT POTENTIAL ACCIDENT ASSESSMENT			E3
INDUSTRIAL ACTIVITY:			8
NUMBER:	ISSUE:	DATE:	
SUBSTANCE:			
POTENTIAL MAJOR ACCIDENT:			

Opportunities for prevention:

Opportunities for control:

Opportunities for mitigation:

Actions proposed or to be taken:

OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY:	1

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Prepared by:	Signature:	Date:

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OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY:	2

NUMBER:	ISSUE:	DATE:

Summary table of potential major accidents

Ref	Brief description	Likeli-hood	Conseq-uence	Comments

OUTLINE SAFETY DOCUMENT			F
CONCLUSIONS			
INDUSTRIAL ACTIVITY:			3
NUMBER:	ISSUE:	DATE:	

Categorised Risk Evaluation (if not completed in Section E2)

Risk matrix for harm to man

Likelihood Category						
	A					
	B					
	C					
	D					
	E					
	F					
		A	B	C	D	E
	Consequence category					

OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY:	4

NUMBER:	ISSUE:	DATE:

Risk matrix for harm to the environment

Likelihood Category						
	A					
	B					
	C					
	D					
	E					
	F					
		A	B	C	D	E
	Consequence category					

OUTLINE SAFETY DOCUMENT			F
CONCLUSIONS			
INDUSTRIAL ACTIVITY:			5
NUMBER:	ISSUE:	DATE:	

Quantitative Risk Evaluation

OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY:	6

NUMBER:	ISSUE:	DATE:

Overall Risk Evaluation

Is the information supplied above complete?

Are the measures which have been identified to prevent, control, mitigate and protect against major accidents adequate?

OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY:	7

NUMBER:	ISSUE:	DATE:

Set out the measures which are suggested/planned such that major accidents will be further prevented, controlled, mitigated and protected against:

20135
(4 of 4)

SRD

SRD. Wigshaw Lane. Culcheth. Cheshire. WA3 4NE.

OUTLINE SAFETY DOCUMENT

FOR MAJOR HAZARD PLANT

IN HUNGARY:

ANNEX 3

ASSESSMENT OF PRODUCTION, STORAGE AND SHIPMENT OF CHLORINE AT BVM, BUDAPEST

Prepared by SRD
January 1993

AEA TECHNOLOGY

OUTLINE SAFETY DOCUMENT	A
IDENTIFICATION	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	1

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Contents

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: A Garlick	Signature: A Garlick	Date: 1/3/93

OUTLINE SAFETY DOCUMENT IDENTIFICATION		A
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		2
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Industrial activity:

This assessment covers the production, storage and shipment of chlorine at the Illatos ut works of Budapesti Vegymuvek in Budapest. It covers the electrolysis plant, the compressing and condensing plant, the storage facilities and on site transport of chlorine to user plants and shipment off site. It does not cover brine dissolution or the user plants themselves.

Manufacturer:

Budapesti Vegymuvek
1097, Budapest, Ken utca 5

Site:

Illatos ut site, Budapest IX.

Purpose of assessment:

Trial assessment to test the Outline Safety Document technique. This is the main purpose of the assessment, and although many results have been gained which would be of use to improve the safety of the activity it is advisable to check the validity of the data and the working before embarking on modifications to plant or operations.

Responsible Person:

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Tel: 0925 254278

OUTLINE SAFETY DOCUMENT	B
APPLICABILITY	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	1

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Attachment List

No	Title	ID	Issue	No Pages	Comment
	None				

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: I Vince	Signature: p.p [signature]	Date: 24/2/93

OUTLINE SAFETY DOCUMENT			B
APPLICABILITY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Is the industrial activity carried out in an industrial installation referred to in Annex I and involving one or more of the substances listed in Annex III?

Yes; condensation; production of non metal by means of electrical energy (Annex I). Chlorine >25te (Annex III)

Does the industrial activity involve storage of one or more of the substances and preparations in Annex II?

Not applicable, since identified as process in previous question

Substances listed in Annex II and Annex III

Number	Chemical Name	Stage of Activity	Quantity	Further Study?
1	*Chlorine*	*All*	*up to 100 te*	*Yes*
2	*Hydrogen*	*Electrolysis*	*up to 150 kg (1500 m^3)*	*No*

Other dangerous substances

Number	Chemical Name	Stage of Activity	Quantity	Further Study?
3	*Mercury*	*Electrolysis*	*66 te*	*No*

Does this information include all quantities of dangerous substances in any group of installations belonging to the manufacturer which are within 500 metres of each other?

No; there are many other processes and stored substances on the Illatos ut site. Furthermore, the BVM Ken utca site lies within 500 m. This aspect needs to be considered in this analysis, and also borne in mind for future work.

OUTLINE SAFETY DOCUMENT		B
APPLICABILITY		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		3
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Does this information include all quantities of dangerous substances in any group of installations belonging to the manufacturer where the distance is not sufficient to avoid, in foreseeable circumstances, any aggravation of major accident hazards?

No - see above.

OUTLINE SAFETY DOCUMENT			C1
LOCAL INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Key to maps*			*2*	
2	*Land use maps*			*3*	*1:14200 and 1:10000*
3	*Notes on location*			*3*	*With references to photos*
4	*Meteorological data*			*6*	*Supplied by SAFEORG*
5	*Location photographs*			*4*	

Revision History

Date	Issue	Comments
16/2/92	1	First issue by SRD

Prepared by: R Ralph	Signature: R. Ralph	Date: 1/3/93

DRAFT C

OUTLINE SAFETY DOCUMENT		C1
LOCAL INFORMATION		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		2
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Factors Relevant to Major Accidents

Is a geographical map of the location attached?

See Attachments 1 and 2. These comprise a number of maps which indicate the position of the site, land use details, population, other hazardous plants and so on. Attachment 3 contains some more detailed notes on aspects of the surrounding area and Attachment 5 supports this with a number of photographs.

In what respect is information missing?

Site locations of specific 'safety' targets are missing, eg schools. There are no hospitals, prisons in the local vicinity (up to 2 km from the BVM site).

Predominant meteorological conditions *(see Attachment 4)*

Wind direction	Probability
N	13%
NE	8%
E	7%
SE	7%
S	9%
SW	9%
W	15%
NW	32%

Stability category	Wind speed	Probability
D	5 m/s	90%
F	2 m/s	10%

OUTLINE SAFETY DOCUMENT	C1
LOCAL INFORMATION	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	3

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Off-site Emergency Plan

Is there an off-site emergency plan for the installation?

> *The current emergency plan is about to be replaced with an improved version which has been prepared as a result of the explosion in January 1992. This plan was not yet in operation at the time of the study and we did not have access to its detailed provisions.*

Name and address of person responsible for maintaining the plan:

> *Not known*

Brief description of the plan:

> *Not available*

Specify the areas in which the emergency plan appears to be deficient:

> *Not known*

Is the plan up-to-date?

> *See above*

Information to the Public

Is information supplied to the public?

Yes

How, and to whom is it supplied?

Open days for the local population and local dignitaries on an irregular and infrequent basis. A monthly newspaper is issued which gives information on the plant and current issues. This is distributed to the local municipal authorities for wider circulation. Any member of the public can visit by making an appointment. The contact number is given in the monthly newspaper.

Does it:

(a) provide the name of the company and the address of the site?

Yes

(b) identify, by position held, the person giving the information?

No

(c) Confirmation that the activity is subject to legislation implementing the Seveso Directive - not yet relevant in Hungary

N/A

(d) explain, in simple terms, the activity undertaken on the site?

No

(e) name the substances and preparations involved on the site which could give rise to a major accident, with an indication of their principal dangerous characteristics?

No

(f) provide general information relating to the nature of the major accident hazards, including their potential effects on the population and the environment?

No

(g) provide adequate information on how the population concerned will be warned and kept informed in case of an accident?

No

(h) provide adequate information on the actions the populations concerned should take, and on the behaviour they should adopt in the event of an accident?

No

(i) confirm that the company is required to make adequate arrangements on-site, including liaison with the emergency services, to deal with accidents and to minimise their effects?

No

(j) refer to the off-site emergency plan(s) above?

No

(l) advise cooperation with any instructions or requests from the emergency services at the time of the accident?

No

(k) supply details of where further relevant information can be obtained?

Yes

C1: ATTACHMENT 1

KEY TO MAPS

BVM SITE.

OTHER INDUSTRIAL/OFFICE SITES

HIGH RISE HOUSING

LOW RISE HOUSING

DERELICT WASTE LAND

FREIGHT TRAIN MARSHALLING AREA.

MARSHALLING TRACK.

2KM FROM BVM SITE BOUNDARY.

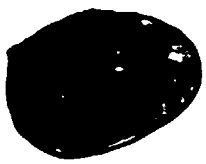
PREVAILING WIND DIRECTION.

(8) POSITION WHERE PHOTOGRAPH WAS TAKEN (SEE ATTACHMENT 5)

DIRECTION OF PHOTOGRAPH.

C1: ATTACHMENT 1

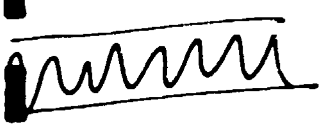
PLANT POSING A CHEMICAL HAZARD.



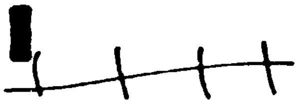
PLANT POSING A FIRE/EXPLOSION HAZARD.

BOUNDARY OF ELECTORAL WARD.

TOTAL INHABITANTS OF ELECTORAL WARD.

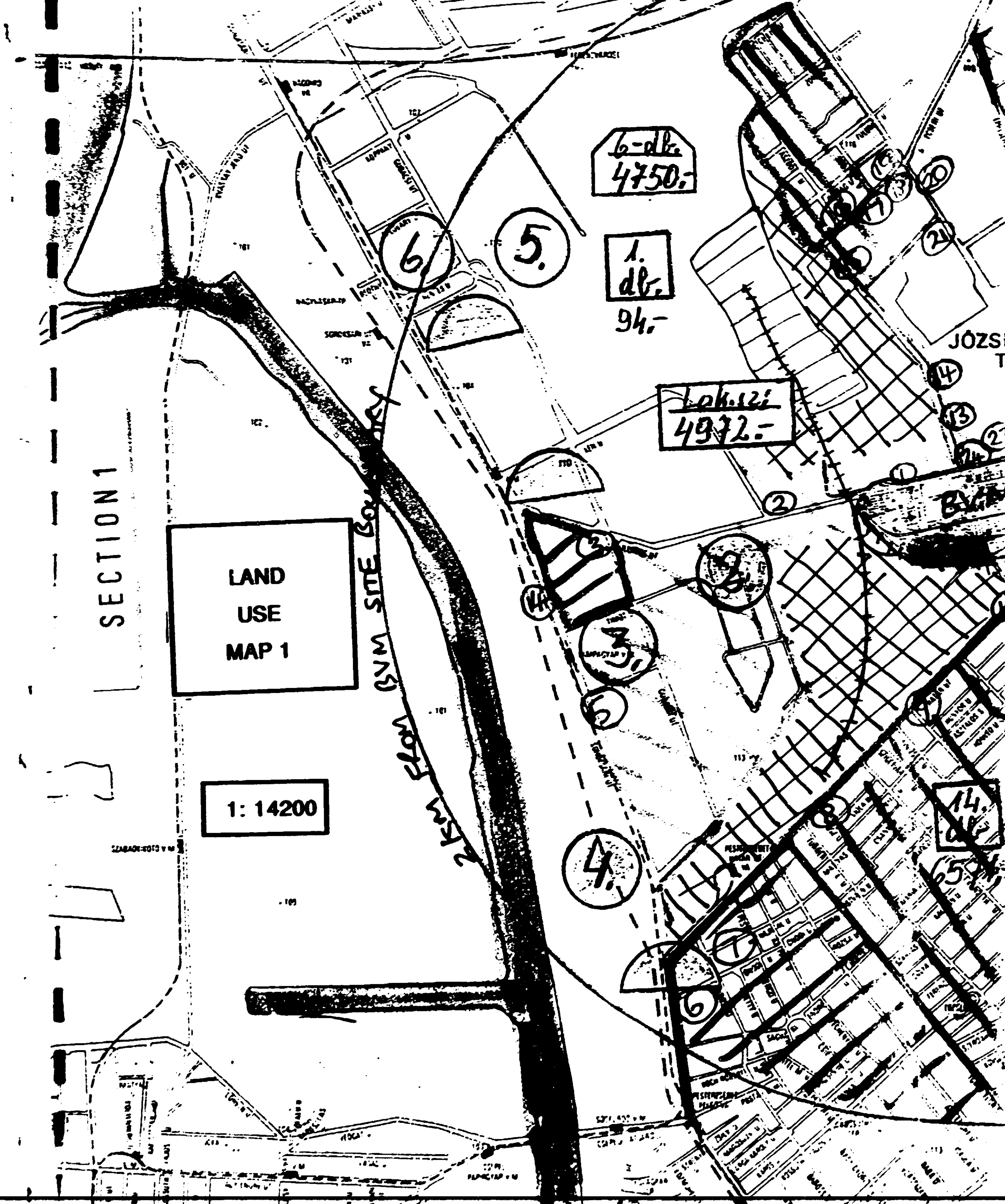


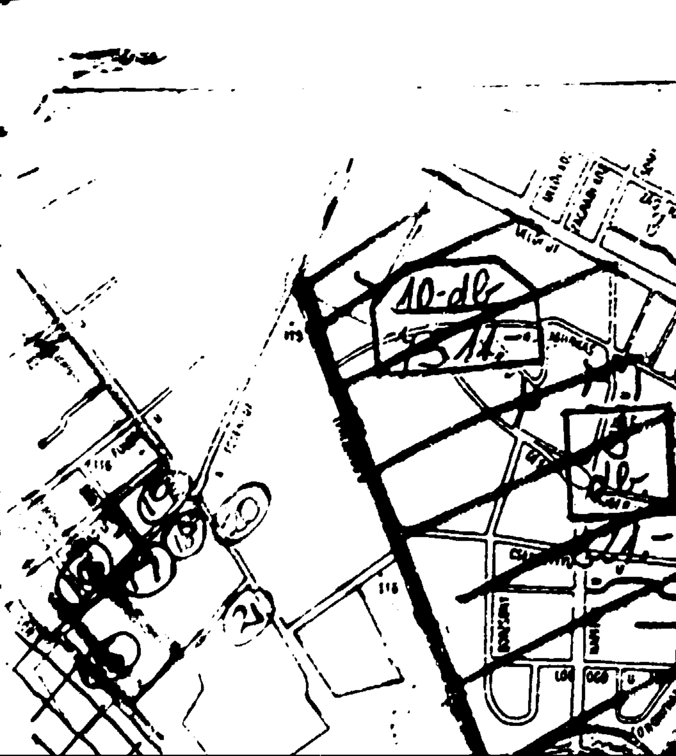
MOTORWAYS

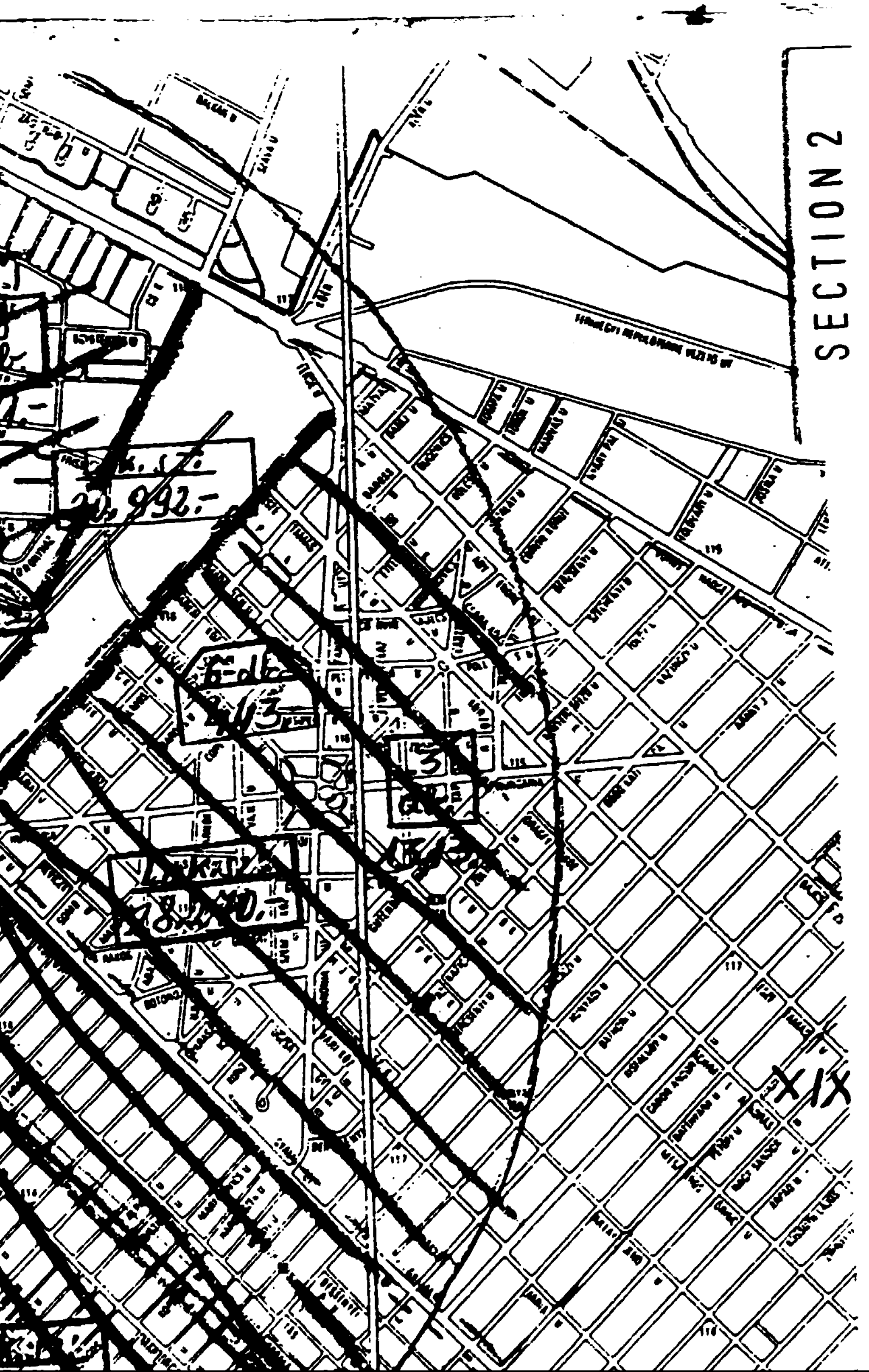


TRAM LINES.

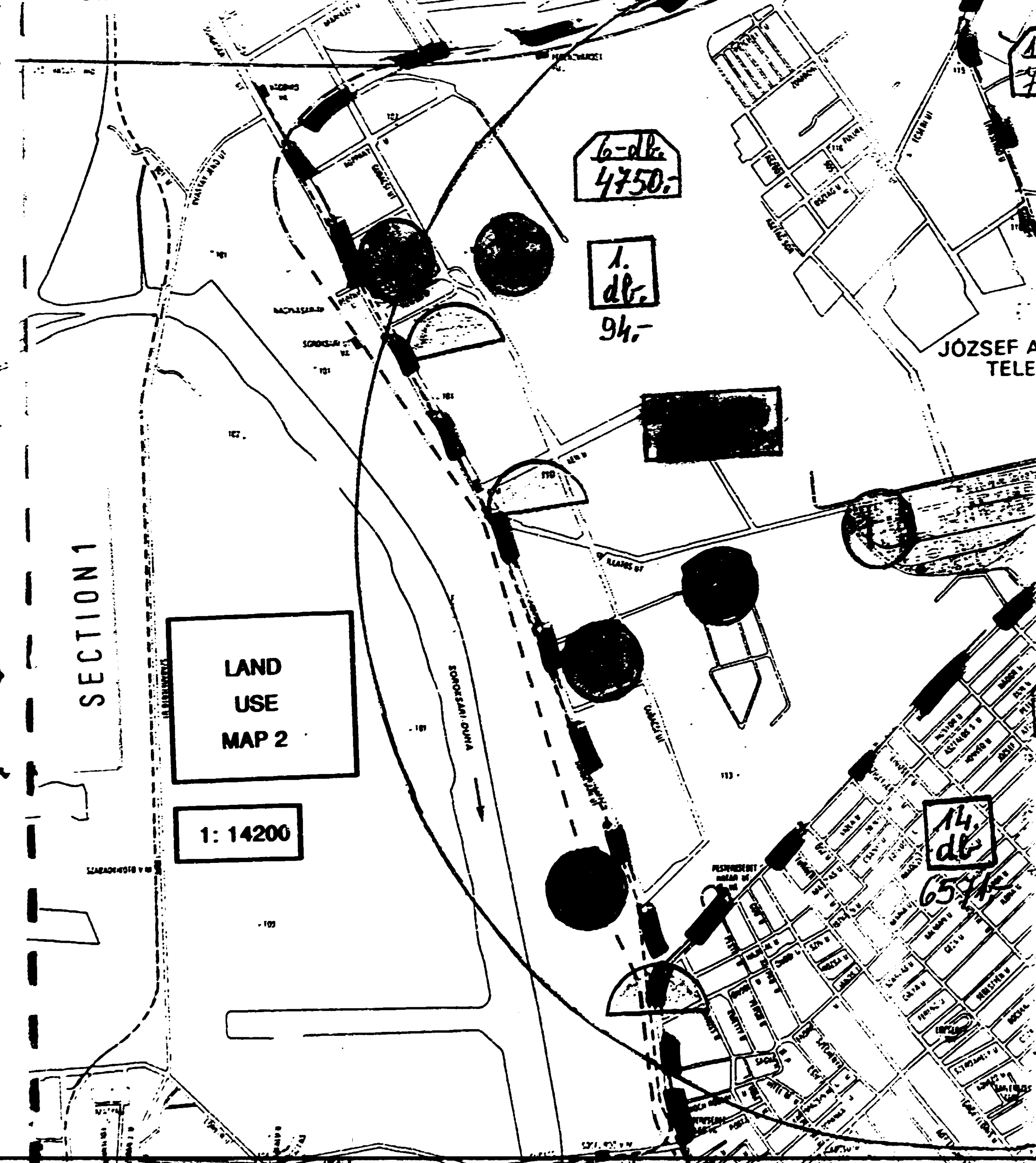
C1: ATTACHMENT 2

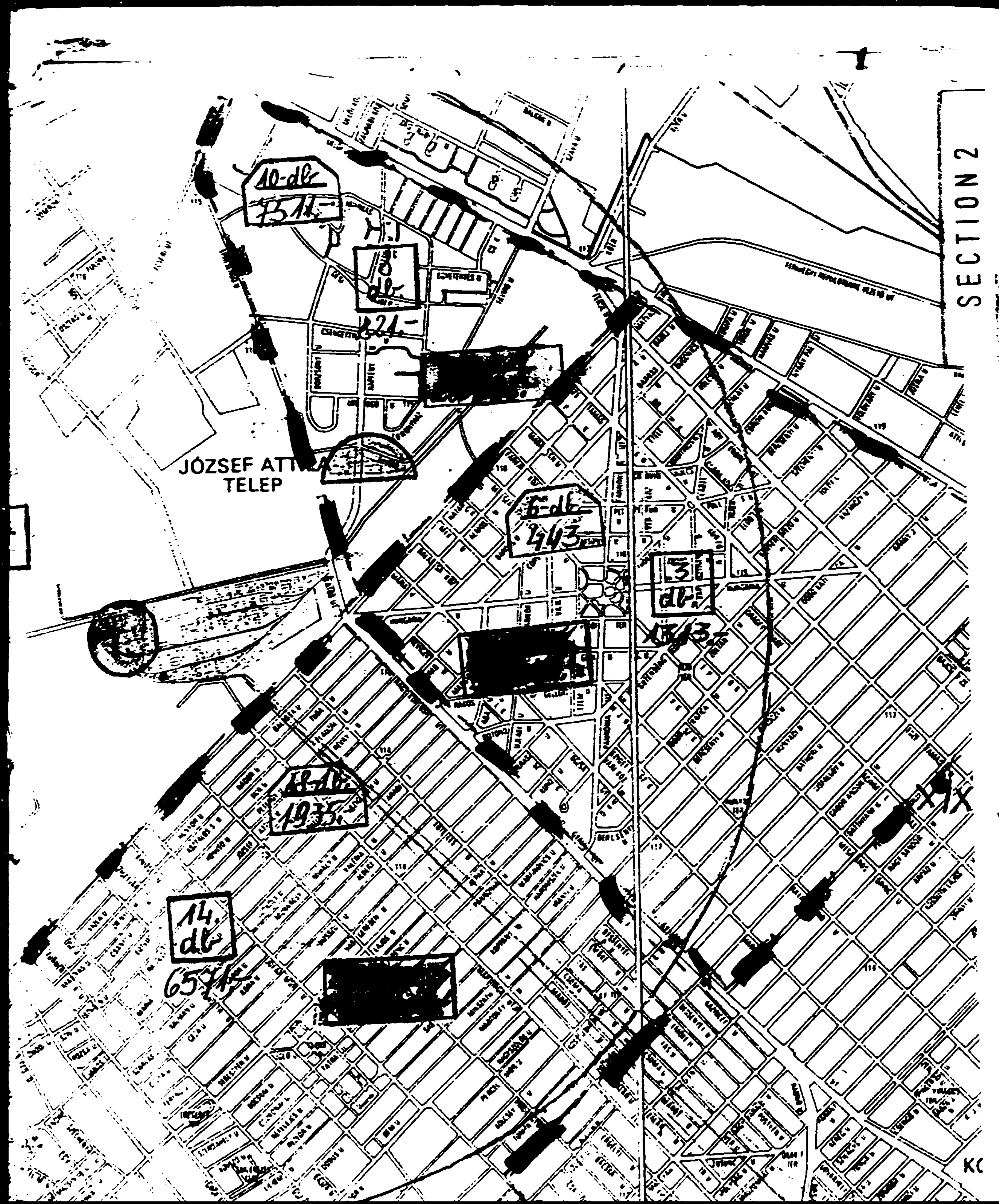



10-dl

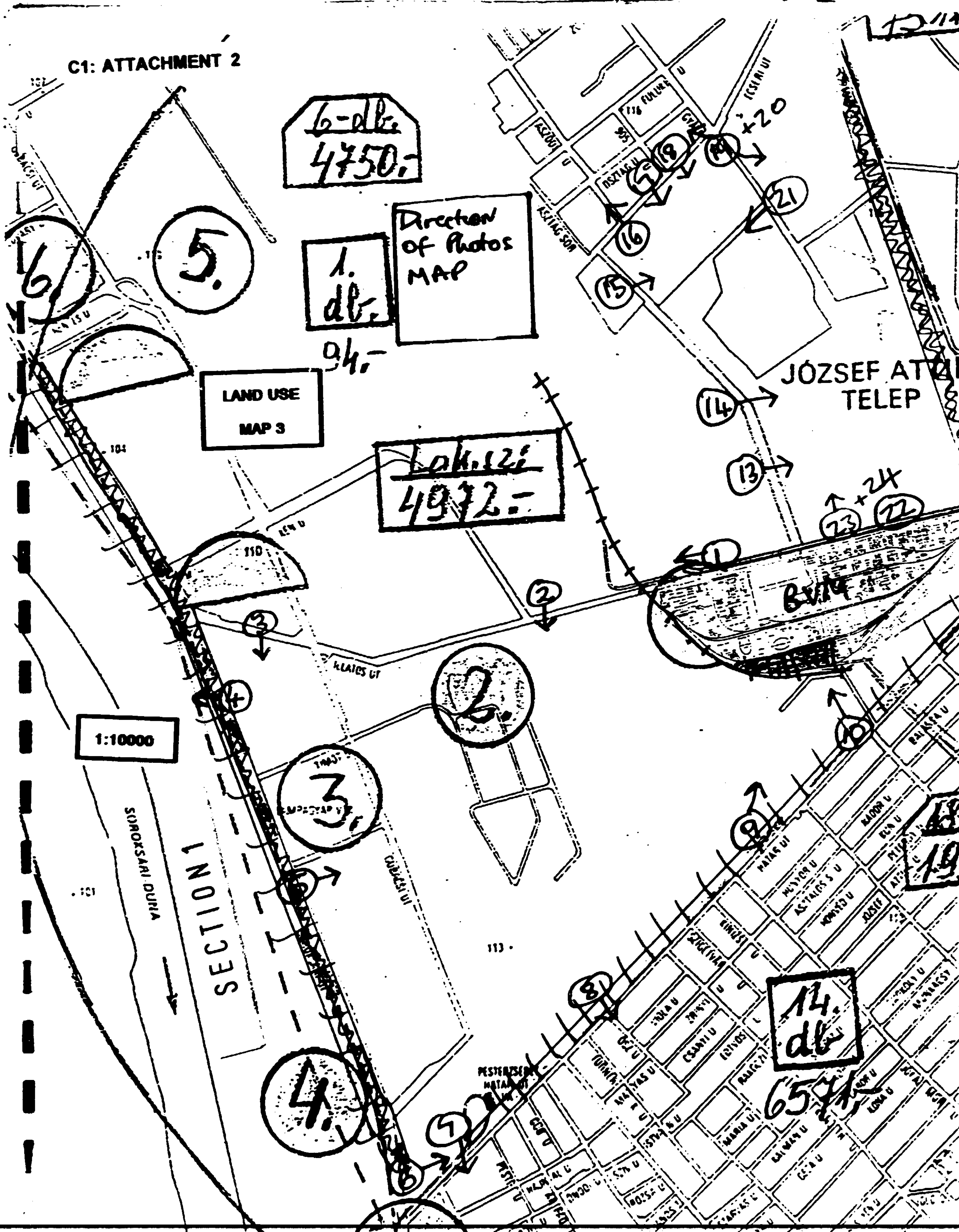

SECTION 2

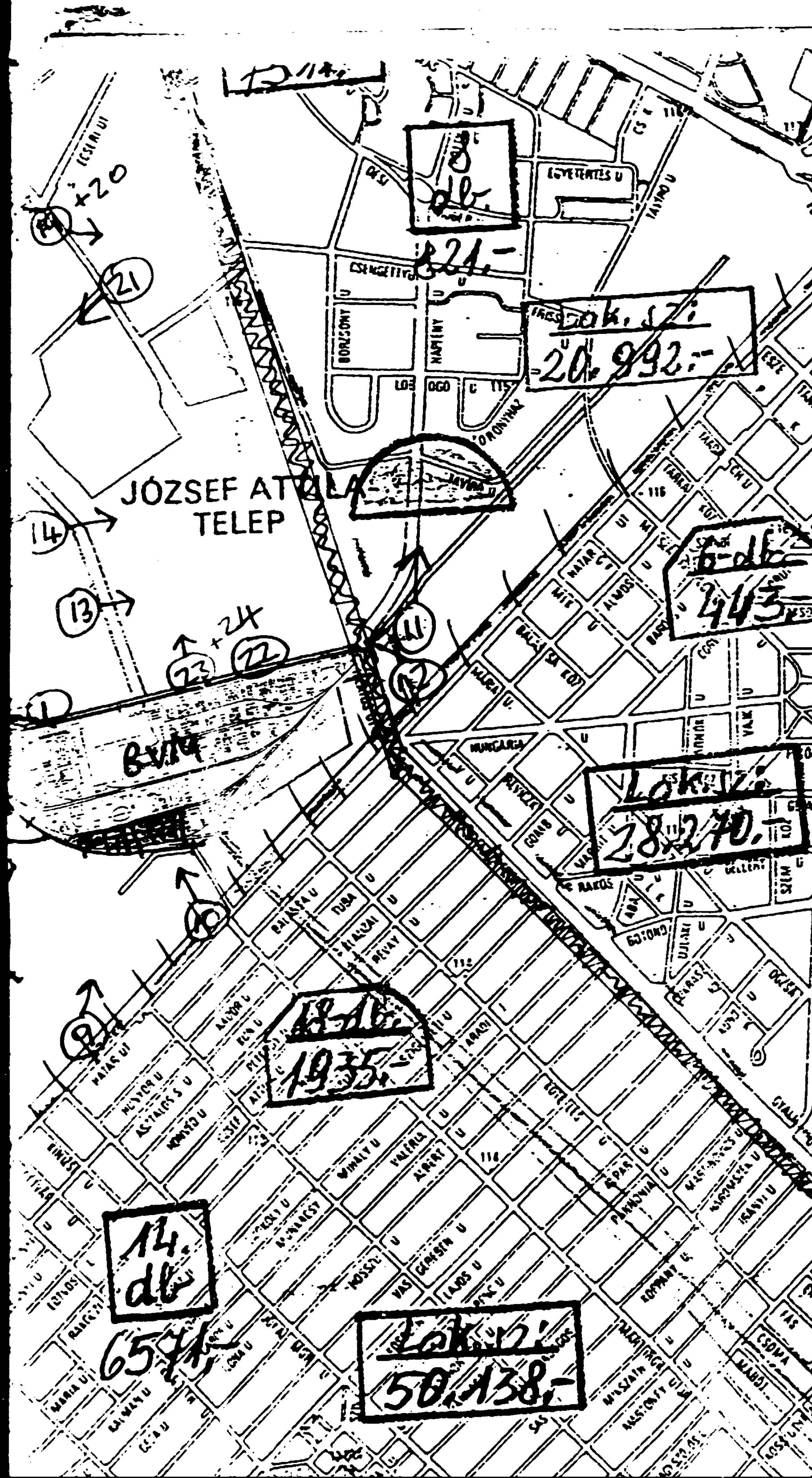
C1: ATTACHMENT 2

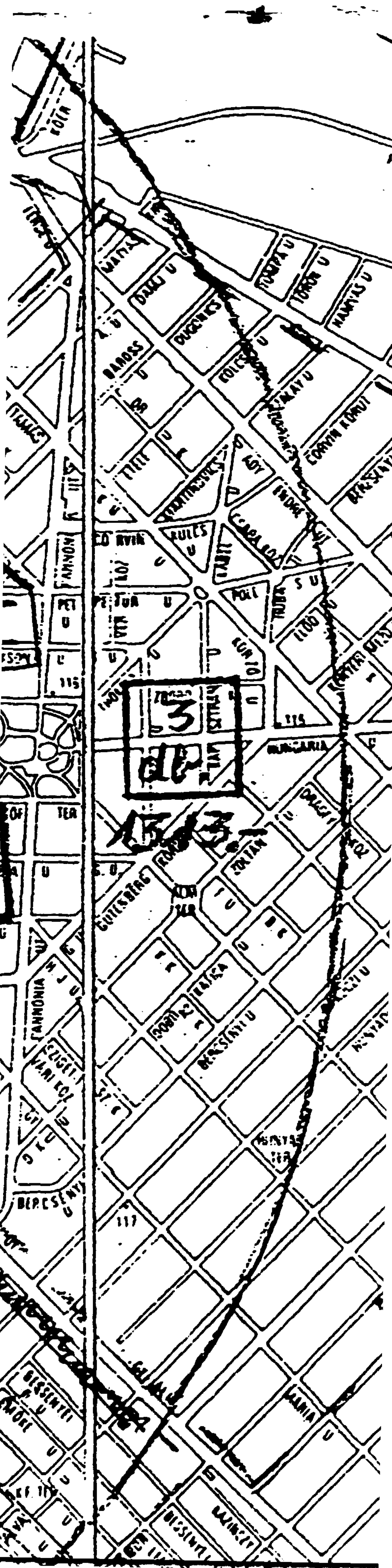



SECTION 2
JÓZSEF ATTILA
TELEP
10-db
3 db
6-db
443
3 db
14 db

C1: ATTACHMENT 2




JÓZSEF ATTILA TELEP
8 db.
821,-
Lak. sz:
20.992,-
6 db
Lak. sz:
28.270,-
18 db.
1935,-
14. db
6571,-
Lak. sz:
50.138,-
EGYETÉRTÉS U
HUNGÁRIA
GOMB U
RÁKOS
TUBA
VALK
UJVIDÉK
CSOMA


HUNGARIA
BERCSENYI U
GUTENBERG
ZOLTAN
115
117

C1: Attachment 3

Notes on Location

Figures in braces [] give photograph numbers.

1 General Off-site Description

High density urban and industrial area. The specific locations of other hazardous plant, offices, factories and housing could be highly significant in estimating the consequences of a major industrial accident on the BVM site.

There is also a high level of general dereliction and waste land, particularly around the southern boundary of the BVM site.

2 Residential Areas

There are 2 main types of housing. High rise/high density housing and lower rise (single storey) high density housing.

The high rise housing [3,6,7,11] is fairly modern and appears to be generally in a good state of condition. There are also wide spaces between each building (50-100 m). However they could pose problems of evacuation, depending upon the type of hazard.

The lower rise housing [8,15,16,24] is potentially an area of greater concern. The streets are relatively narrow and there is very little space between each house. Most of this housing is also in a poor condition. This type of housing lies in the prevailing wind direction from the BVM site.

There was also some evidence of temporary/shelter accommodation in the derelict areas. The number of people affected appears to be small, but given the difficulty in sending information and communicating with these people in the event of an emergency further investigation in this area may be important.

3 Industrial Areas

The main industrial areas are to the North and South West [2,5,13,14,17,18,20, 21,23]. We only have work force numbers for the hazardous companies, however there are large numbers of offices and warehouses and there is soon to be a supermarket to the North. Based upon a very superficial study we estimate a further 5000 to the workforce giving a total of 10,000. Given the plans for new buildings and factories in the area one may assume that the workforce is likely to increase. It is difficult to judge how many also live within the 2 km radius of BVM.

4 Schools

There are potentially 40 schools within the 2 km radius of BVM based upon figures from each electoral ward. However some of these wards extend beyond the 2 km *radius. It appears some are high rise [19] and would pose problems for evacuation.*

5 **Population Density**

The population figures from the electoral wards total 105,000. Given that appropriately 30% of the 2 largest wards are outside the 2 km radius, we reduced this by 30,000 giving an estimate of 75,000 inhabitants. In addition to this are 10,000 (workforce) and 4,000 (pupils, estimate based upon a total of 16,000, 4,000 coming from outside the 2 km radius and therefore adding to the daytime population), giving a population density of over 7000 km^{-2}. We also estimated the population density in the low-rise residential areas to be around 9000 km^{-2}. This is based on dividing the total population in the two wards (78,000) by the total area of the wards.

6 **Environment**

There appears to be only one significant environmental target in the local vicinity, a loop of the river Danube which forms Csepel Island. This loop is used for recreational activities and fishing. Contamination of the loop may be possible, depending upon the local drainage system, from both routine releases and accident conditions (see section D). It is likely that water is extracted from the loop for industrial use on Csepel Island.

The aquifer may also be an important environmental target. Wells near the banks of the Danube are used for drinking water in Budapest. Contamination and subsequent movement of groundwater near BVM may pose an environmental hazard. In particular mercury contamination, for which BVM have been repeatedly fined by the local inspectorate, may be important.

It is understood that the groundwater depth on the BVM site is about 4 m.

7 **Other Hazardous Plant**

A number of other hazardous plants exist in the local vicinity but only one, an acetylene plant [2] appears to pose an escalation hazard to BVM. This plant is marked number 2 on map Attachment 2, page 2).

8 **BVM** [9,10]

The 2 km "Hazard Range" as determined by the local authorities has been based upon a maximum release of 150 te of chlorine or 30 te of hydrogen fluoride. It is not common for either quantity to be found on site. This year the average is between 80 and 100 te of chlorine.

The chlorine plant in BVM is located in the southern area of the site. It is separated from the nearest residential area by 300 m. The housing in the immediate vicinity is of the low rise (single storey) type.

A recently built motorway [12] is also close to the site boundary. A very busy road [4] can also be found to the West of the site, as well as Illatos ut itself and Hatar ut *which forms the boundary of the nearest housing.*

A number of offices and warehouses can be found to the North and East of the site [2,13,14,17,20,21,23]. They may be difficult to evacuate in the event of an accident.

6. Metecrological data

The meteorological data needed for the consequence analysis were obained from the HAZOP investigation of the flourination plant by Vegyterv in 199o. Considering that the data represented averages of lo and 5o years, we did not think it was necessary to obtain new data.

Meteorological data used for consequence analysis

Atmospheric stability:	instable			neutral		stabile
Stability category	A	B	C	D	E	F/f*+
Occurence (%)	no data					

Occurence assumed during the investigation:

D category 9o %

F category lo %

Wind directions

Direction	N	NE	E	SE	S	SW	W	Nw
Occurence (%)	13	8	7	7	9	9	15	32

(Comment: We consider the direction from which the wind is blowing as the dominant. We have no data on still-wind occurence.)

16405003, D16

Wind speed

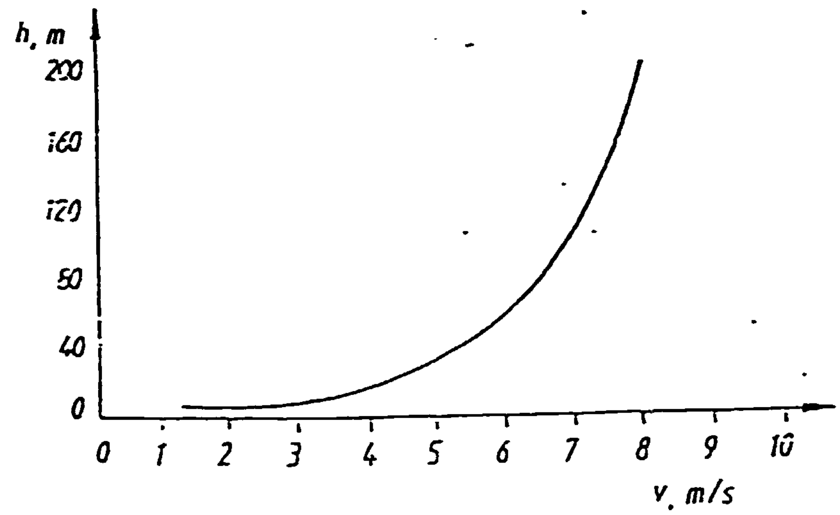
We have no data about stability categories and distribution of the wind speed according to wind directions.

Assumed wind speed in case of D category: 5 m/s
Assumed wind speed in case of F category: 2 m/s

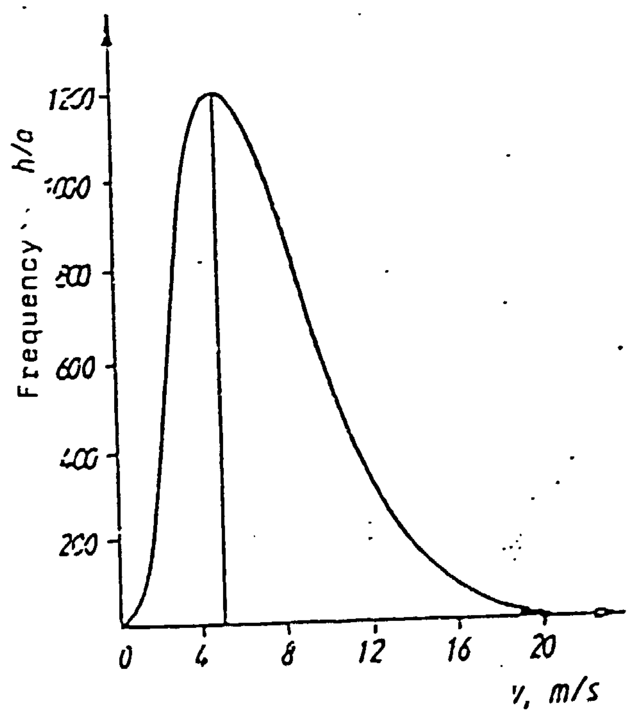
Air temperature: - 11 °C to + 30 °C
We took the air temperature to be + 20 °C in the analysis.

Relative humidity: 71 %

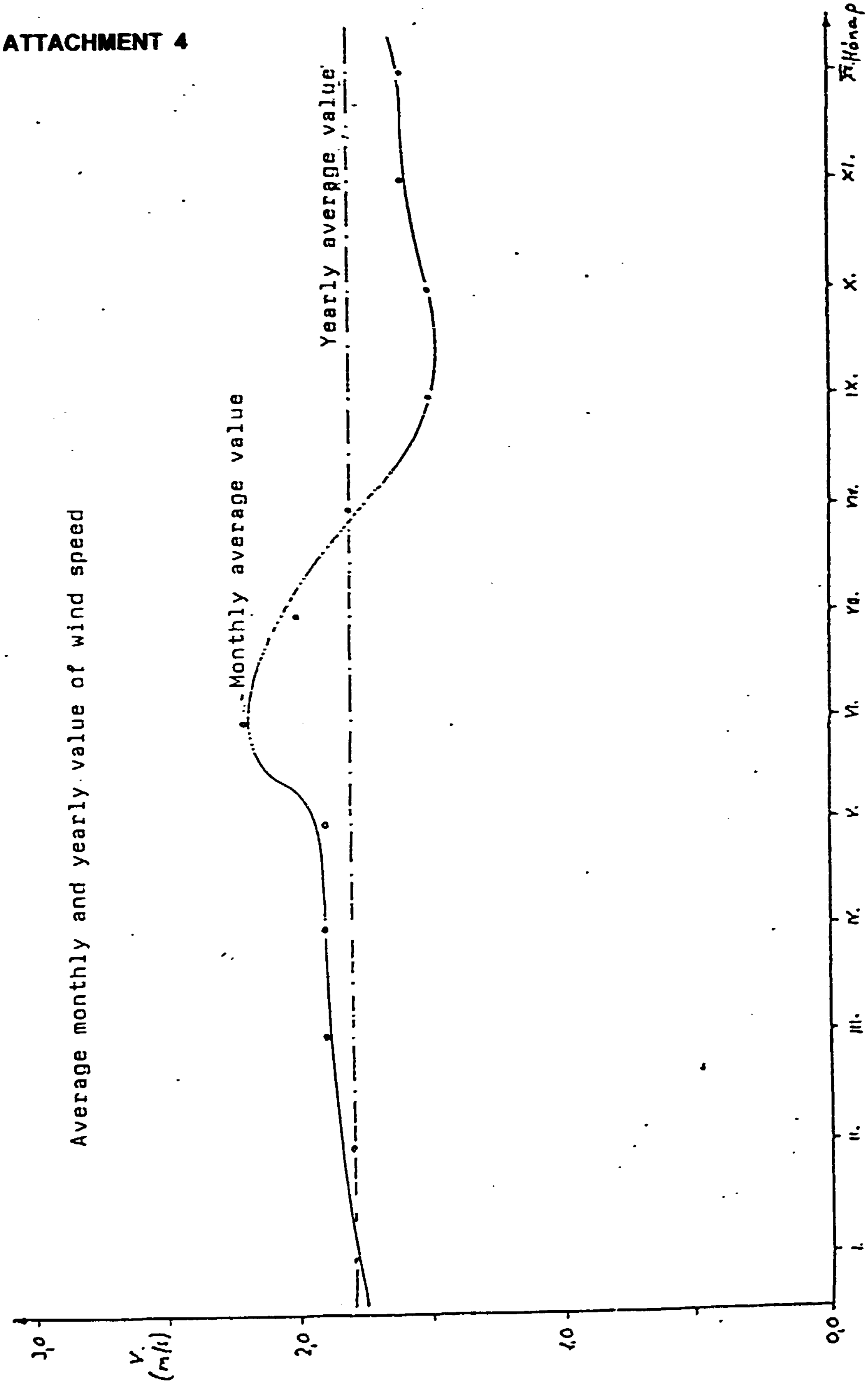
The annual average wind speed as a function of height above ground level



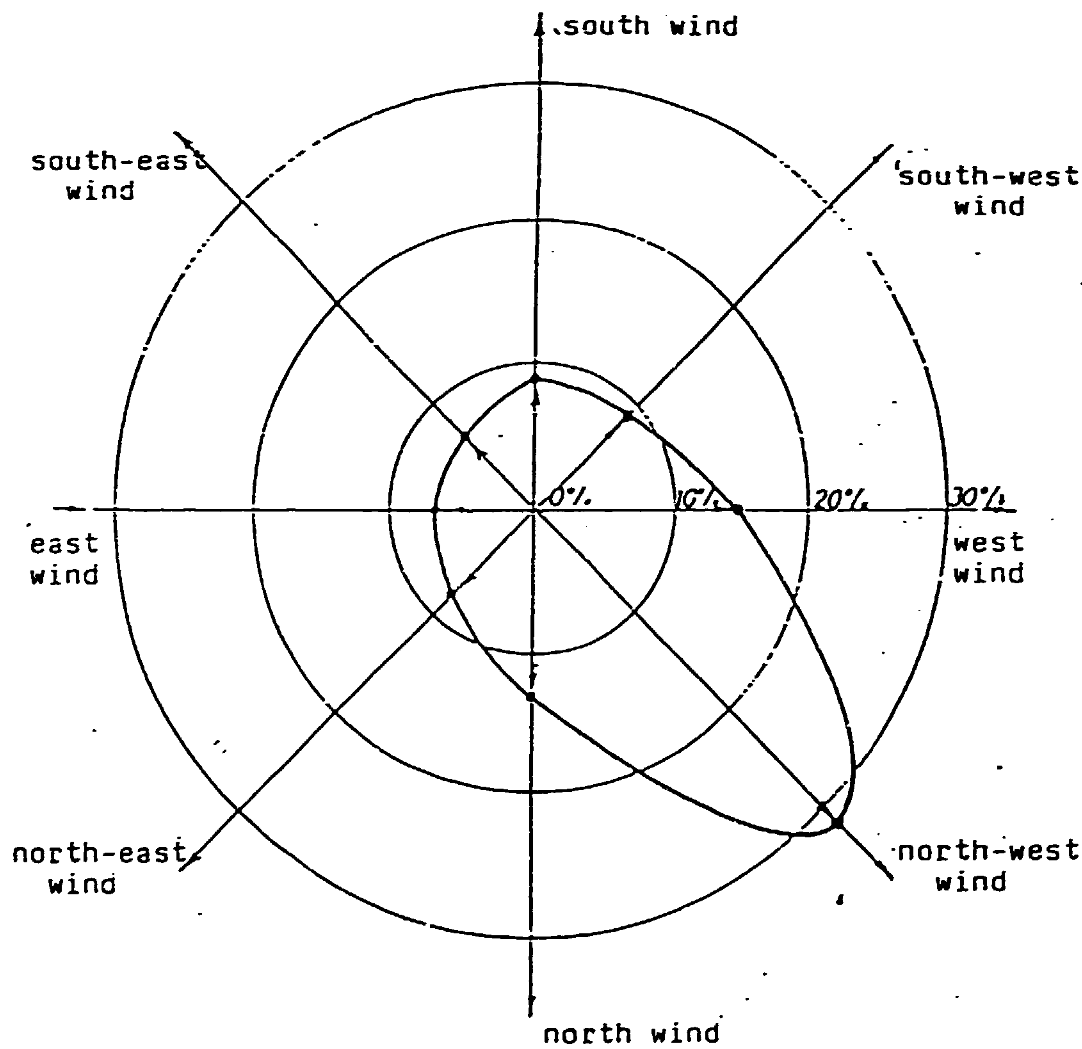
Frequency of wind speed.

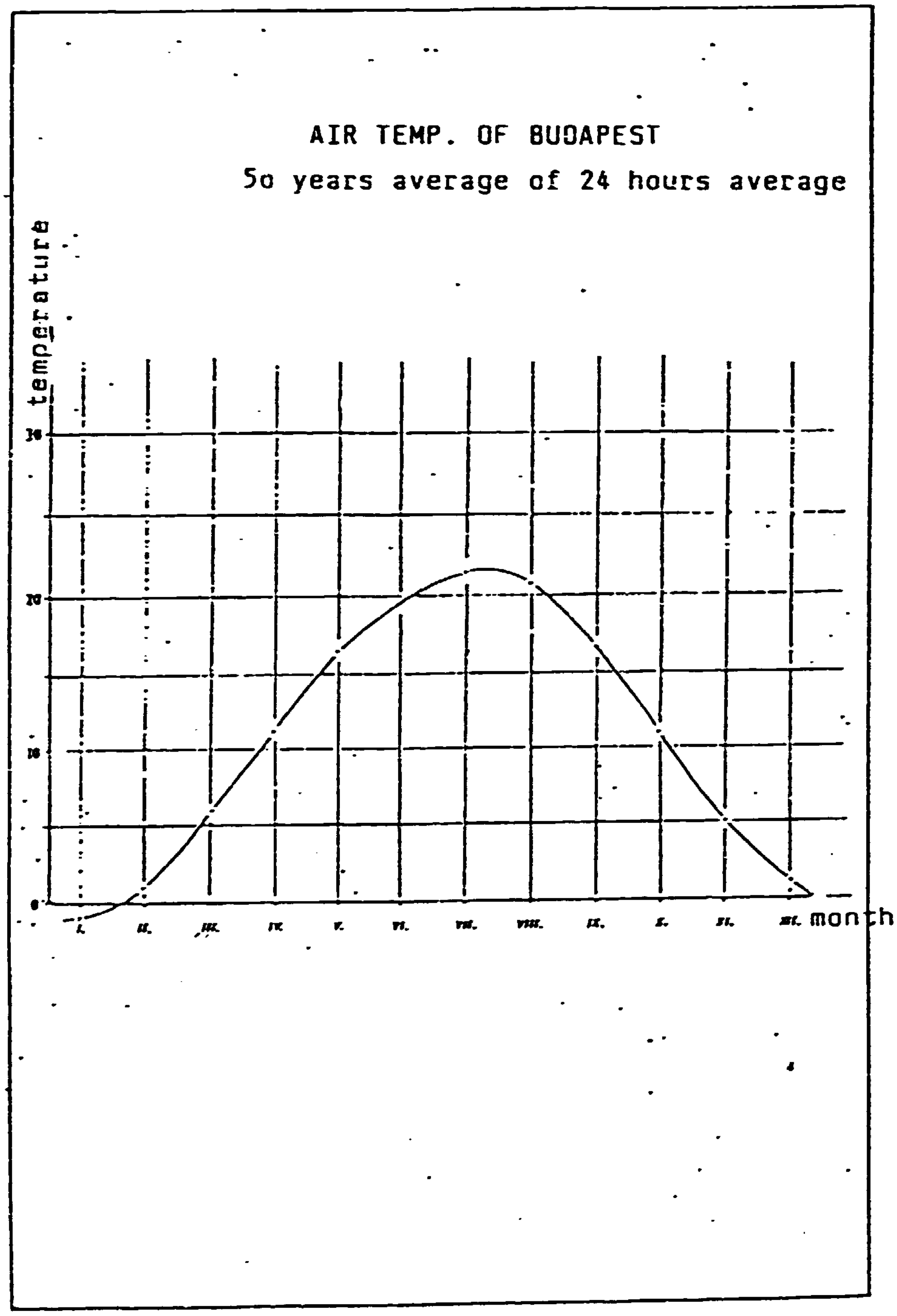


C1: ATTACHMENT 4

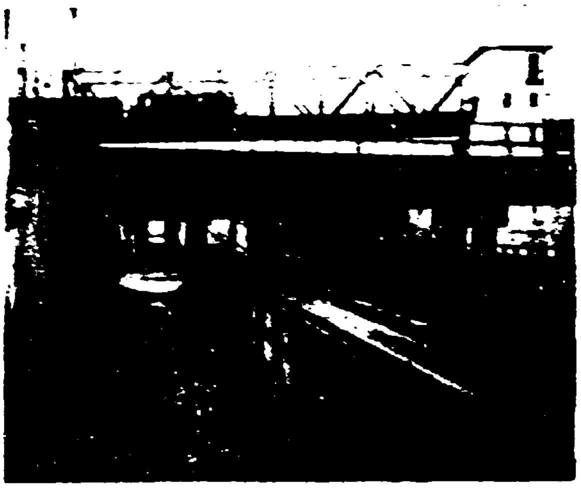


Yearly wind conditions frequency in Budapest
based on to years average




AIR TEMP. OF BUDAPEST
5o years average of 24 hours average
temperature
month

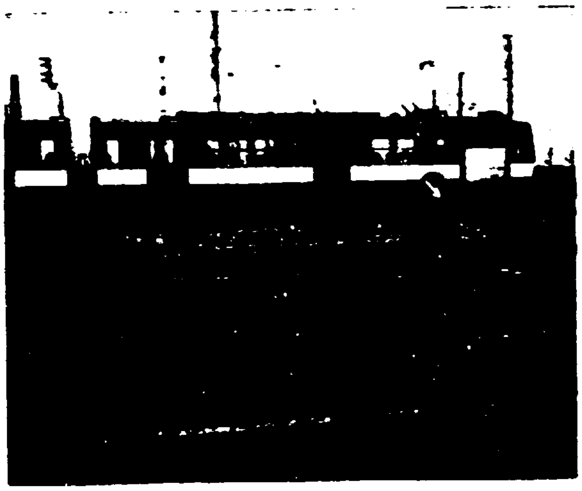
C1: ATTACHMENT 5



1

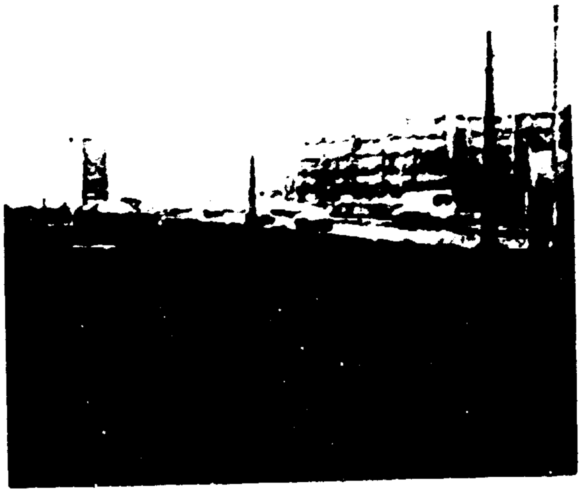
2

3



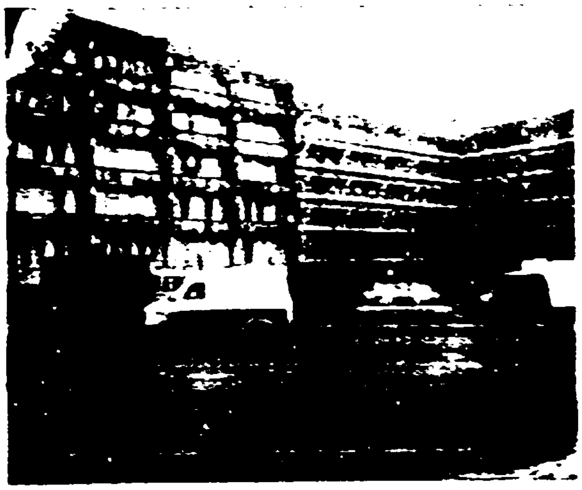
4

5



6

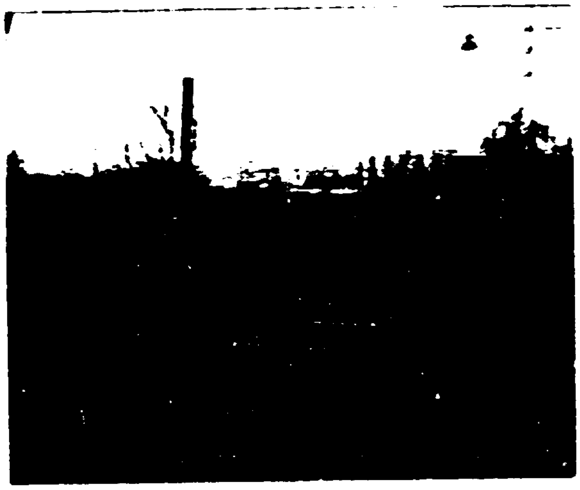
C1: ATTACHMENT 5



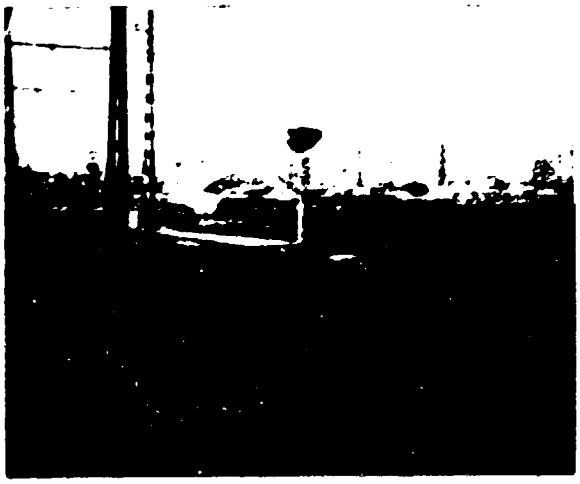
7

8

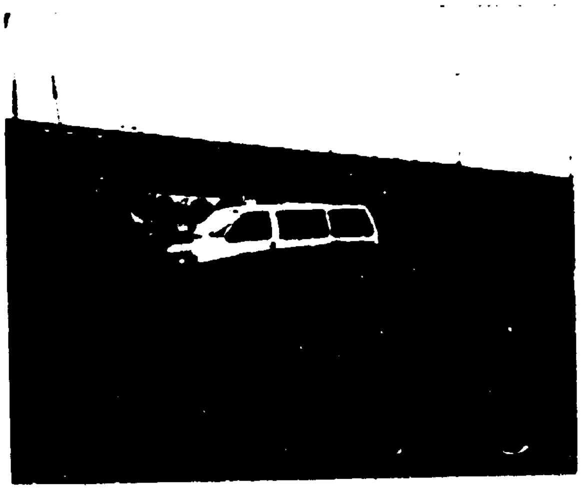
9



10



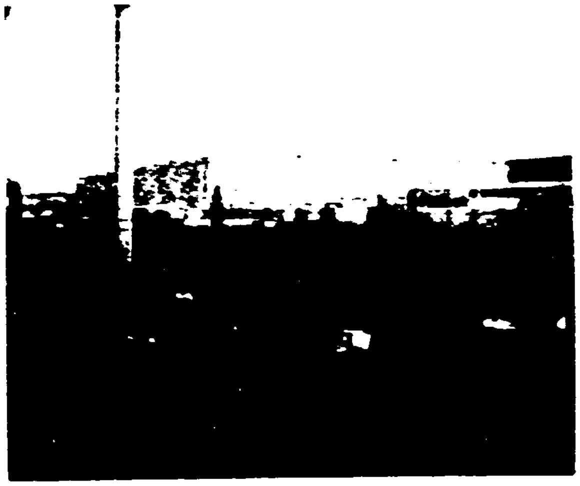
11



12

C1: ATTACHMENT 5

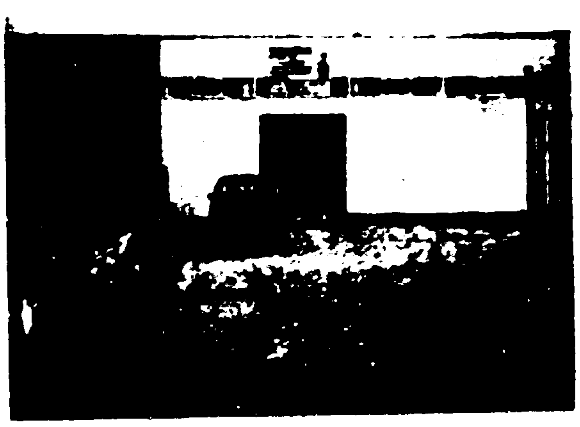
13



14

15

16

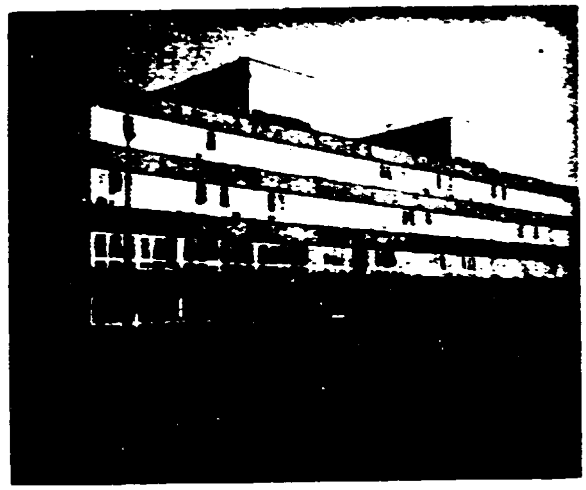


17

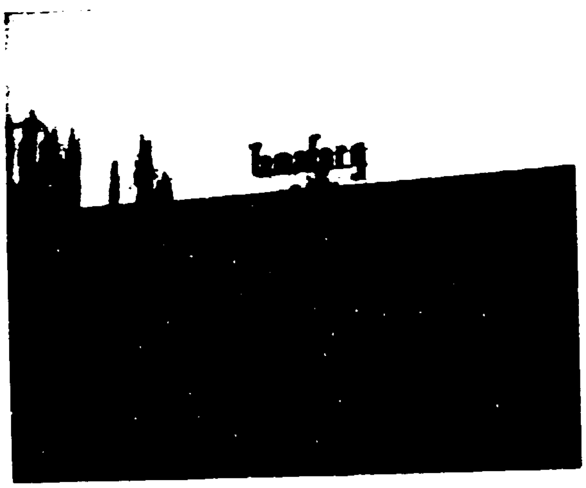
18

C1: ATTACHMENT 5

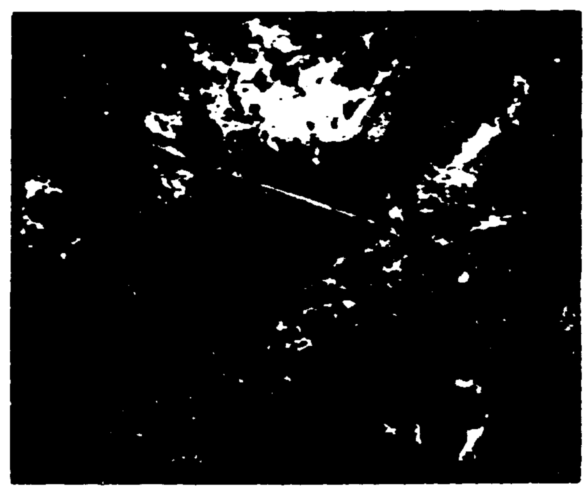
19



20



21



22

23

24

OUTLINE SAFETY DOCUMENT			C2
SITE INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Site plan*	*26.681*	*6/11/90*	*1*	*Scale 1:1000*
2	*Key to site inventories*		*5/92*	*4*	*In Hungarian*
3	*P&IDs and keys*			*17*	*Prepared for study.*
4	*Production flowsheet*			*1*	

Revision History

Date	Issue	Comments
16/2/92	1	First issue prepared by SRD

Prepared by: I Vince	Signature:	Date: 2/12/93

DRAFT C

OUTLINE SAFETY DOCUMENT			C2
SITE INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Site and Process Description

Is a site plan attached?

Yes. See Attachments 1 and 2

In what respects is information missing?

- *Liquid Chlorine in pipework = 0.2 te*
- *Offices and organic plant (numerous staff) ca. 300 m to NE.*
- *Approximately 20 people for part of day at HCl export bay, which is very near.*

Maximum number of persons on site:

Permanent employees:	*603*
Contractors:	*50*
Temporary staff:	*5*
Visitors:	*12*

Describe the industrial activity:

Production of chlorine by electrolysis of brine; after drying and compression, the majority of the chlorine is burned with hydrogen (also produced in the electrolysis) and dissolved in water to form hydrochloric acid, with (usually) lesser amounts being used in BVM's organic plants on the same site, or being condensed, stored and eventually exported as liquid chlorine in rail tank cars, drums and cylinders. Waste gases containing chlorine are routed to react with sodium hydroxide solution (again, an electrolytic by-product), forming sodium hypochlorite. A simplified flowsheet is provided as Attachment 4.

With reference to Attachment 1, the two cell rooms are marked (29) (old) and (29) (new). (33) is the building where the chlorine is compressed, condensed and stored in 4 x 25 te tanks. The drum and cylinder shipment area is (34), the hypochlorite plant is (35) and the HCl plant is (36). The hydrogen produced in the electrolysis is stored in a tank at (30).

More detailed P&IDs are provided in Attachment 3.

OUTLINE SAFETY DOCUMENT			C2
SITE INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			3
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Main items of safety critical equipment and their location:

- hypochlorite plant to dispose of routine and accidental emissions of chlorine (needs to be available at all times).
- compressors to extract chlorine from electrolysis process (if these shut down an automatic system shuts down chlorine production).
- extraction systems from chlorine compressing and condensing facility.
- natural circulation to extract chlorine from electrolysis rooms.

Note we were not provided with detailed information on how high availability of these systems is achieved.

On-site Emergency Plan

Is there an on-site emergency plan?

Yes - in draft - to be finalised and approved February 93

Brief description of emergency plan:

1. *Introduction to site - road approaches; nature of neighbourhood; site population etc.*

2. *Process upsets; incidents*
   - minor: definition, examples, responsibilities (½ page)
   - major: definition (½ page)
   - catastrophic: lists possible scenarios (generic) on filling/emptying.

3. *Most hazardous materials; state and quantities on site (Cl_2, HF).*

4. *Definition of catastrophe (realisation of major hazard) - loss of ≥ 20 te Cl_2/HF. Procedure on catastrophic loss of containment (5 steps).*

5. *Raising the alarm. Procedure, including notifications - emergency services etc.*

6. *Procedure after major process upsets, including composition and tasks of emergency committee and of groups reporting to this committee.*

Annexes: *Properties of Cl_2, HF.*

OUTLINE SAFETY DOCUMENT			C2
SITE INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			4
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Inventory of hazardous items.
Inventory of emergency equipment, including PPE, available on site.
List of nearest industrial neighbours and their most hazardous materials.

Specify the areas in which the plan appears to be defective:

The plan seems insufficiently detailed in most sections. The following have not been adequately addressed:

- *Hazards from liquid SO_2 (Ken utca)*
- *Means of identifying emergency*
- *Access for emergency services*
- *All aspects of fire fighting*
- *Communication links*
- *Evacuation arrangements*

The draft plan has many errors, some of critical importance (eg omission of HF storage from inventory).

Is the plan up-to-date?

Yes

Are affected people, including contractors and visitors, informed of its provisions?

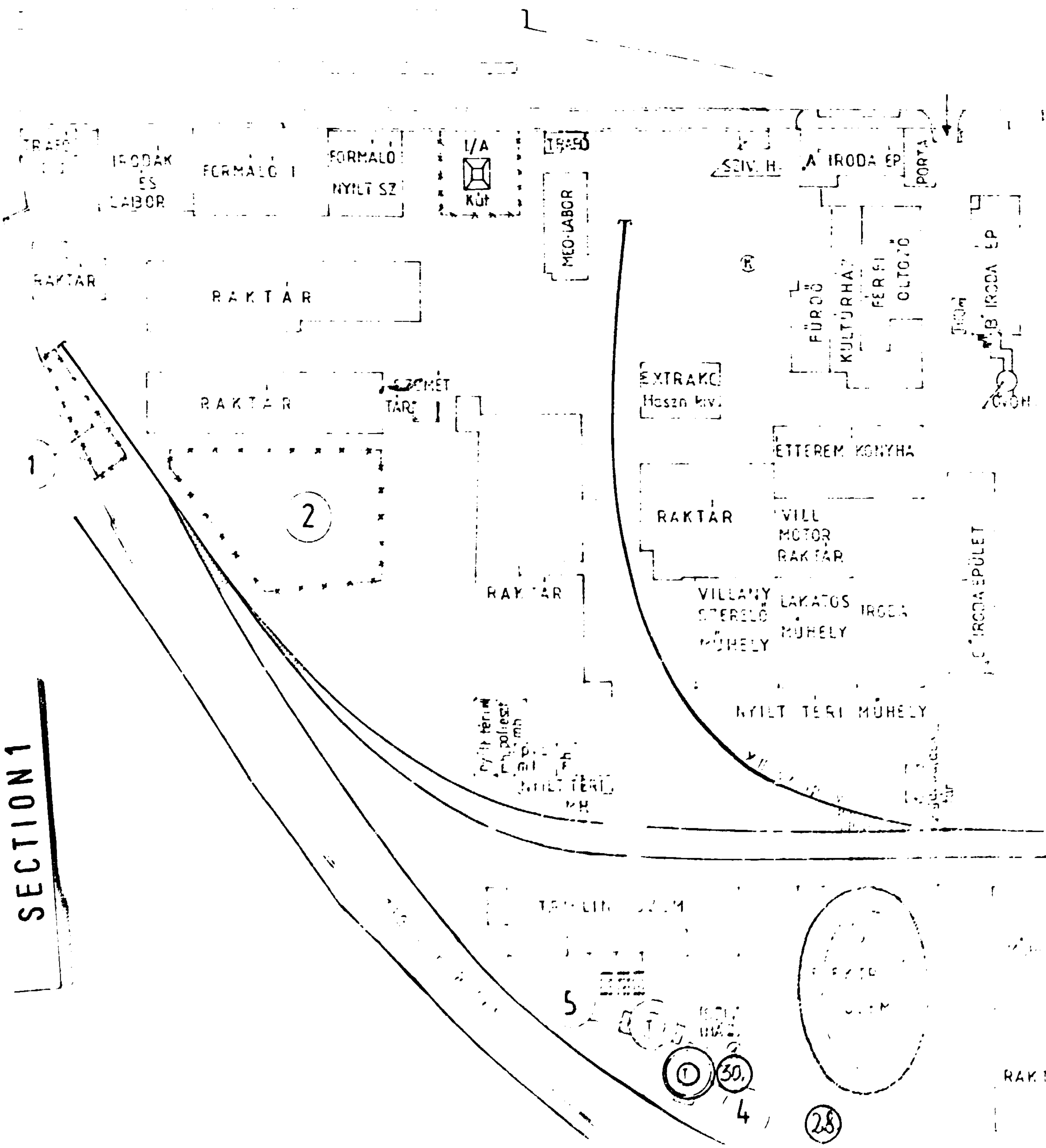
Permanent staff yes, visitors no - but visitors are continuously accompanied.

Is the plan rehearsed?

Yes - annually (but see Section D)

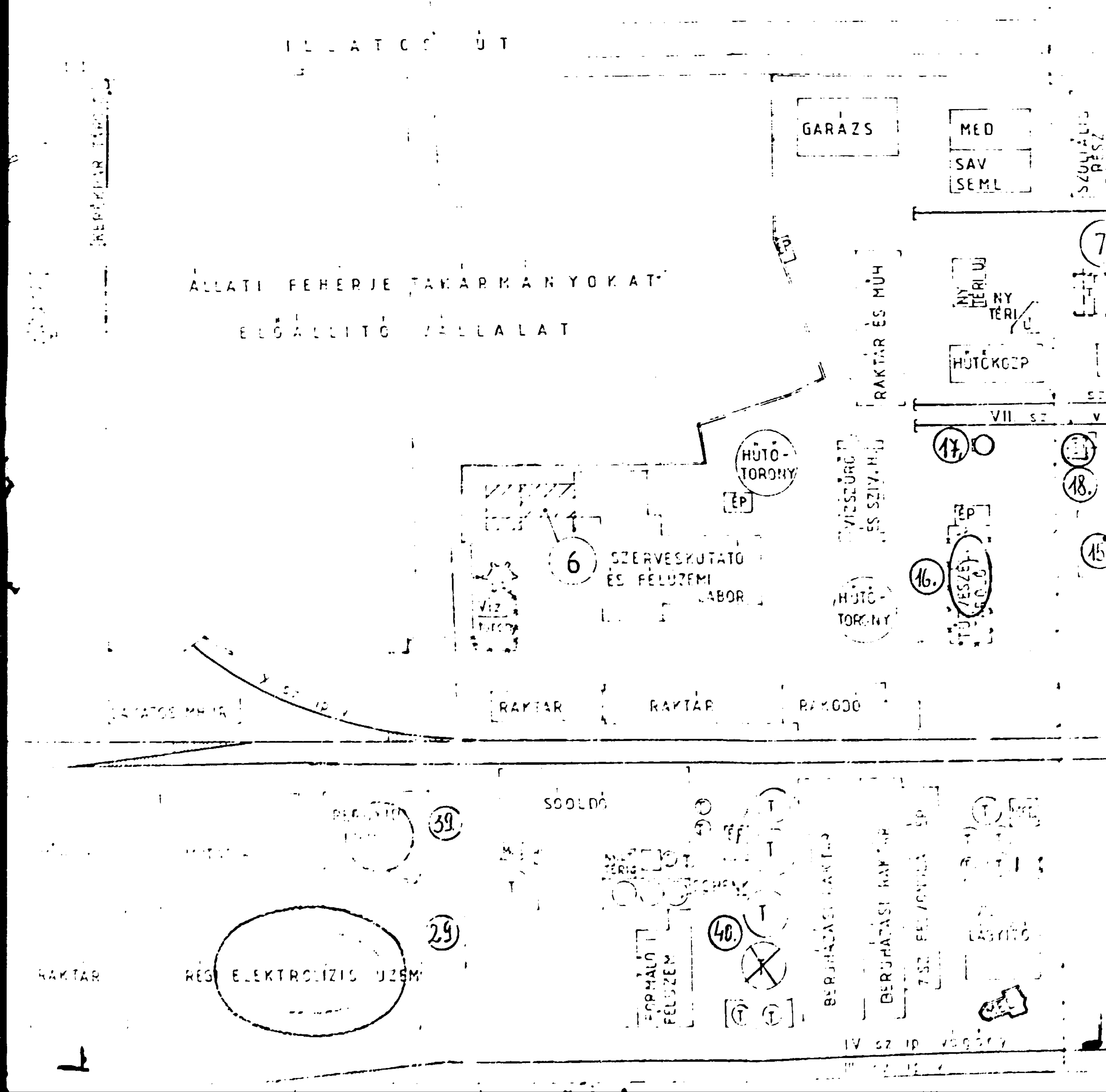
Do the off- and on-site emergency plans match?

Not known


TRAFÓ
IRODÁK ÉS LABOR
FORMÁLÓ I
FORMÁLÓ NYÍLT SZ
I/A
Kút
TRAFÓ
MEO-LABOR
SZIV. H.
A IRODA ÉP
PORTA
B IRODA ÉP
FÜRDŐ
KULTÚRHÁZ
FÉRFI ÖLTÖZŐ
RAKTÁR
RAKTÁR
RAKTÁR
SZEMÉT TÁR
EXTRAKC.
Haszn. hiv.
ÉTTEREM KONYHA
RAKTÁR
VILL MOTOR RAKTÁR
RAKTÁR
VILLANY SZERELŐ MŰHELY
LAKATOS MŰHELY
IRODA
IRODAÉPÜLET
NYÍLT TÉRI MŰHELY
NYÍLT TÉRI MH
1
2
5
4
30
28
SECTION 1

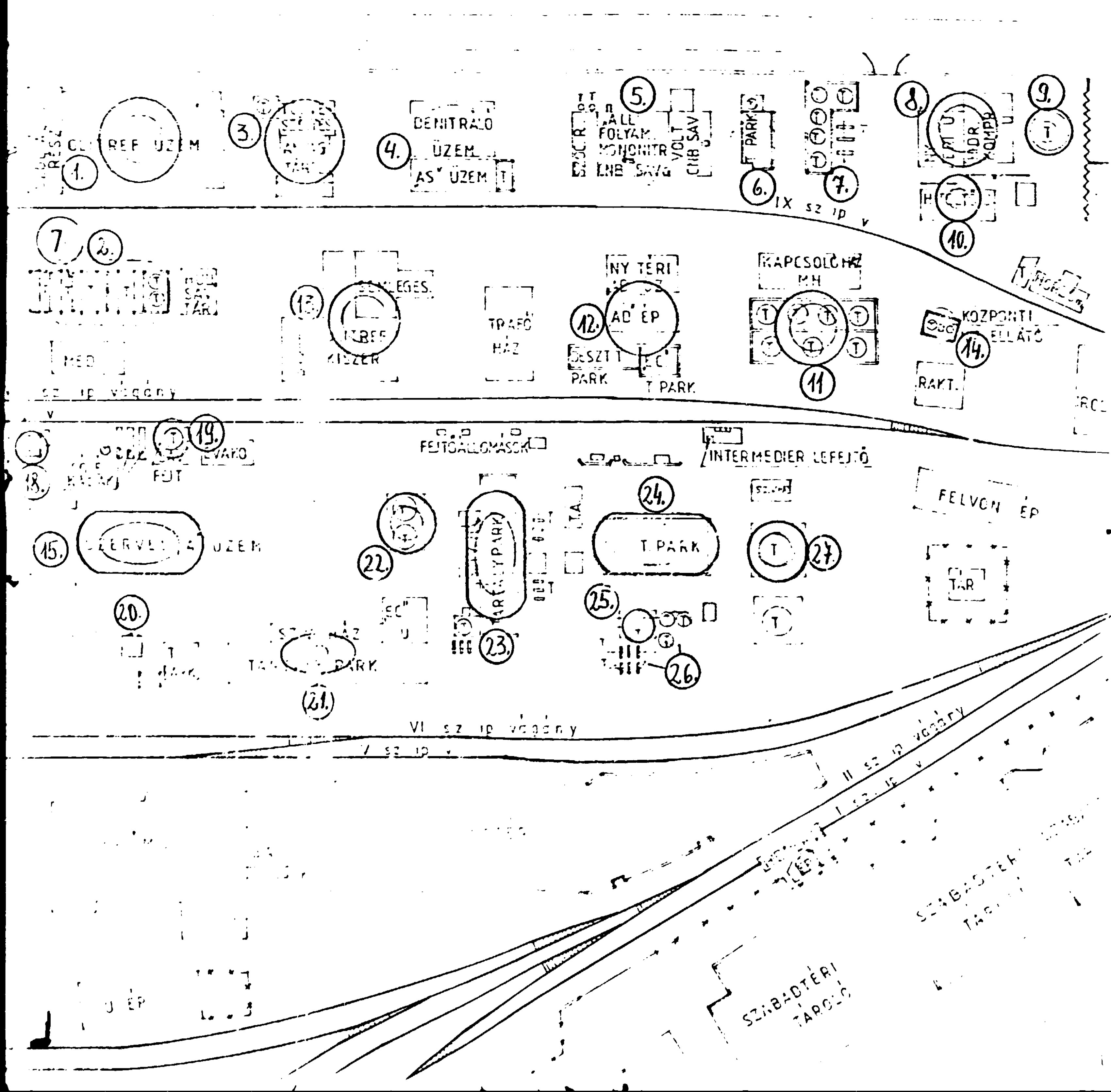
SECTION 2

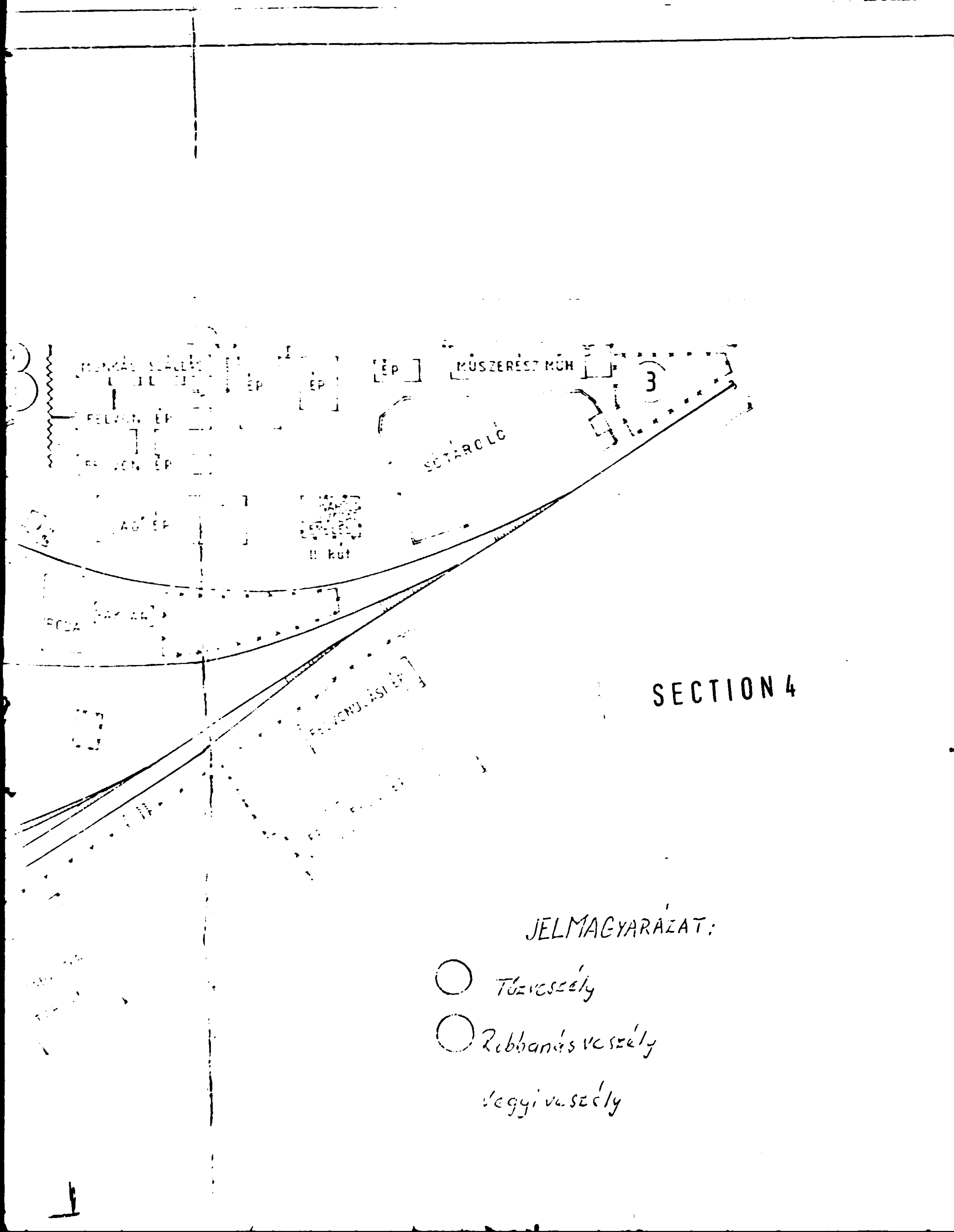
VESZÉLYES ANYAGOK F

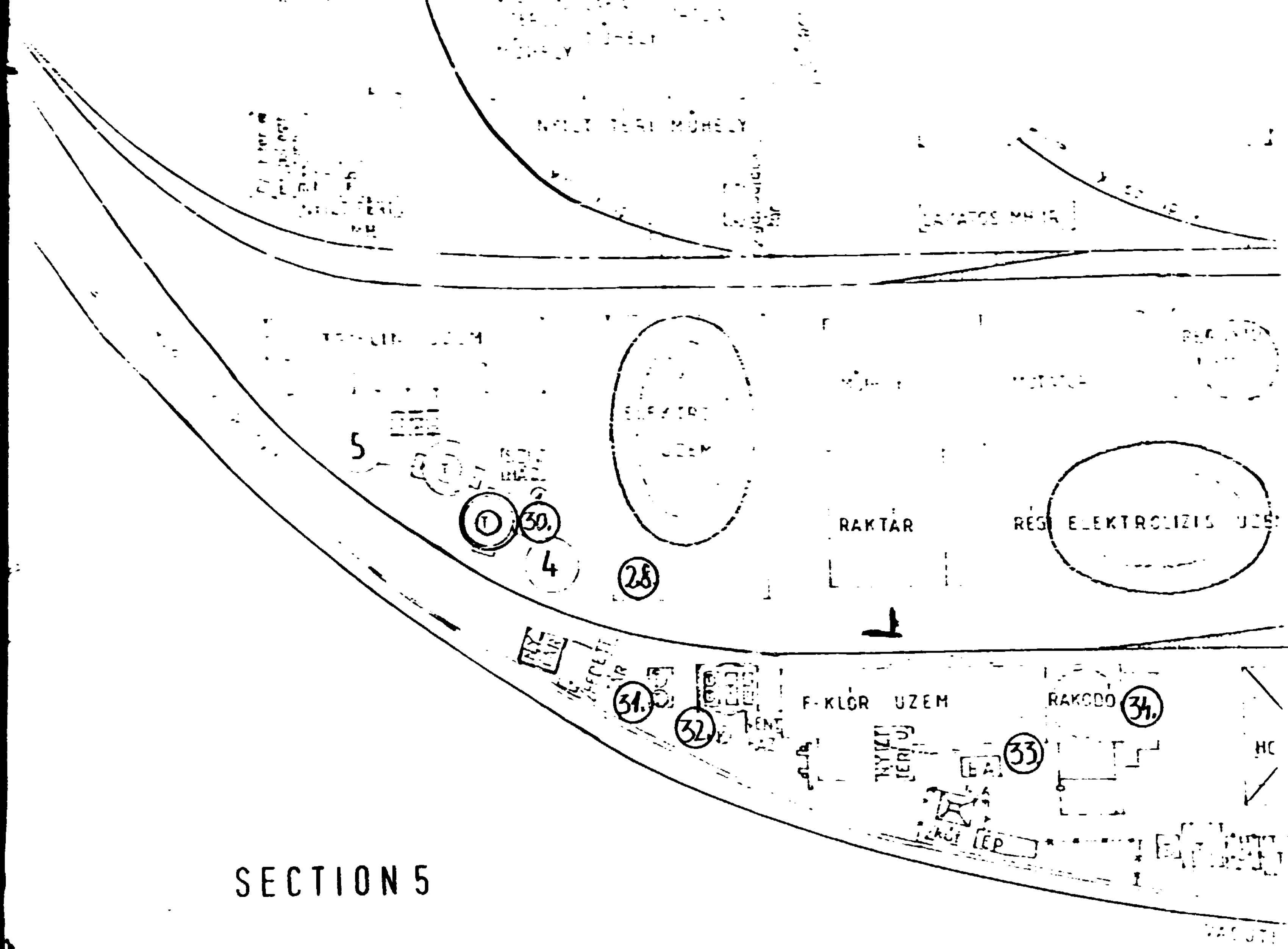


FELHASZNÁLÁSA ÉS TÁROLÁSA

SECTION 3

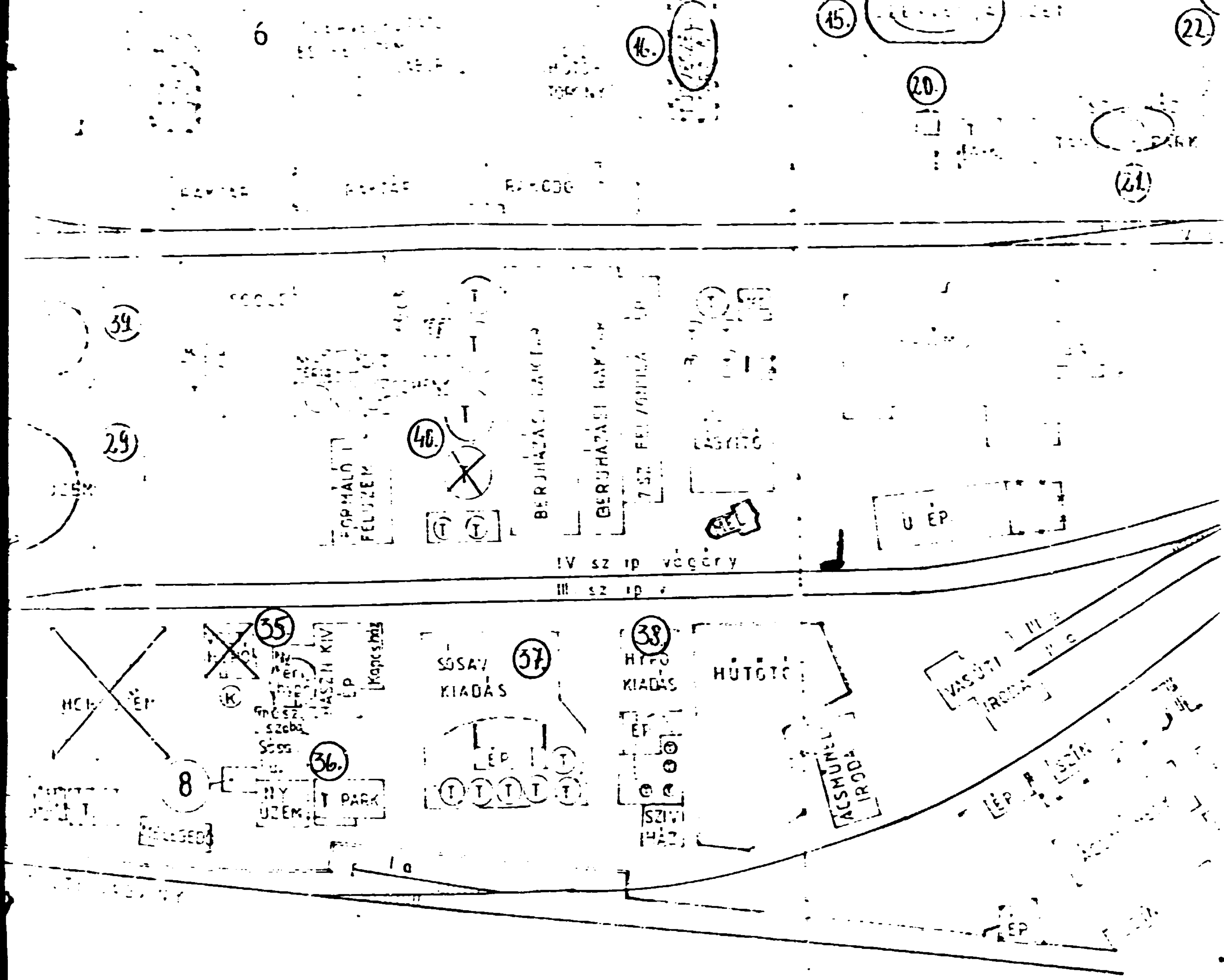



ÉP
ÉP
ÉP
MŰSZERÉSZ MŰH
3
FELVON. ÉP
SECTION 4
JELMAGYARÁZAT:
Tűzveszély
Robbanásveszély
Vegyi veszély



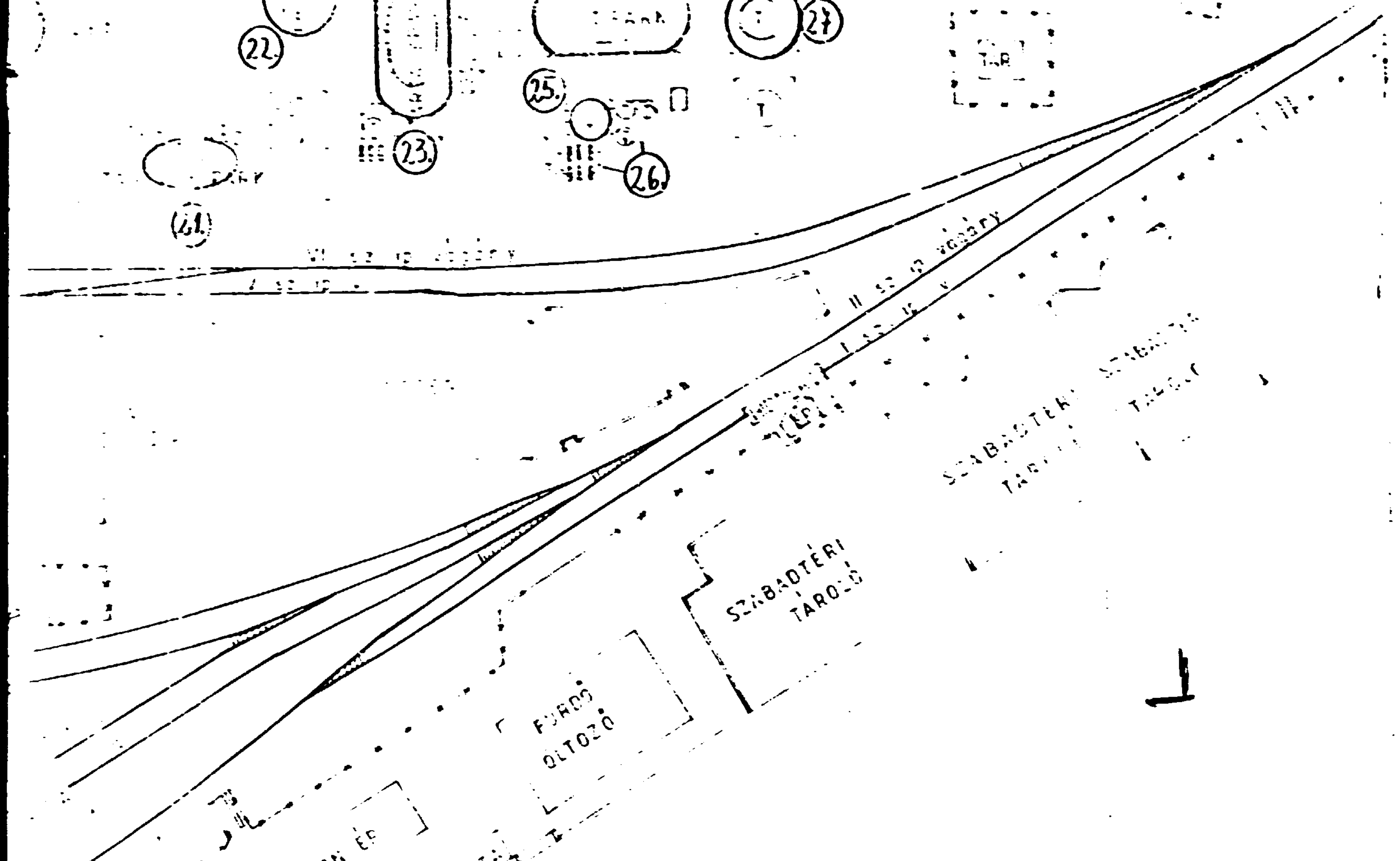
SECTION 5

1 ÁTMENETI TÁROLÓ TELEP
2 TERVEZETT TÁROLÓ TELEP
3 ÁTMENETI TÁROLÓ TELEP
4 I sz MEGLÉVŐ GÁZOMÉTER
ÚJ ROBBANÁSGÁTLÓ VÉDŐFALA
5 II sz MEGLÉVŐ GÁZOMÉTER
ÚJ ROBBANÁSGÁTLÓ VÉDŐFALA
6 FOTOKLÓROZÓ KISÉRLETI FÉLÜZEM
7 OLITREF TARTÁLYPARK
8 HIDROGÉNFÚVÓ HÁZ



6
FORMÁLÓ FELÜZEM
IV sz ip vágány
III sz ip
SÓSAV KIADÁS
HŰTŐTŐ
VASÚTI IRODA
ÁCSMŰHELY IRODA
T PARK
Ú ÉP
ÉP

SECTION 6



JELÖLÉSEK

MH	=	MŰHELY
T	=	TARTÁLY
SZIV.HÁZ	=	SZIVATTYÚHÁZ
K	=	KÉMÉNY
HIDM.	=	HIDMÉRLEG
ÉP	=	ÉPÜLET
MED.	=	MEDENCE
NY. TÁR.	=	NYÍLT TÁROLÓ
BA.	=	BETONALAP
TA.	=	TARTÁLY ALAP
Ü.	=	ÜZEM
NY.TÉRI	=	NYÍLTTÉRI
TÁR.	=	TÁROLÓ
GA	=	GÉPALAP
TA.	=	TARTÁLYALAP
HASZN. KÍV.	=	HASZNÁLATON KÍVÜL

SECTION 7

JELMAGYARÁZAT:

○ Tűzveszély

○ Robbanásveszély

Vegyi veszély

SECTION 8

É

1990. II. 6.

C2: ATTACHMENT 1

1:1000

BVM ILLATOS ÚTI TELEPE RENDEZÉSI TERV.

26.681

ILLATOS

1640J003.DS

[redacted]

- 1 -

C2: ATTACHMENT 2

Sorszám:	Veszélyes anyag megnevezése:	Mennyisége:	Tárolás módja:	Tűzv. Fok.	Megjegyzés:
1.	Benzo-Trifluorid Para-Klór-Benzótriklorid Hidrogén Flourid Aromatol	10 t 2 t 0,7 t 1 t	Olitref üzem Technikai rendszerben	"A" "C" "B"	[illegible]
2.	Salétromsav Kénsav Oleom Hulladéksav	40 t 70 t 70 t 120 t	2 db 20 m³-es alu.tartály 1 db 50 " ac. " 1 db.50 " ac. " 2 db.50 " ac. "	"E"	
3.	DPA Ditropil - amin. Aromatol Dietil - amin.	25 t 18 t 7 t	2 db 25 m³-es rm.ac.tart. 1 db.25 " " 2 db. 5 m³-es "	"B"	
4.	Hulladéksav Keveresav	50 t 25 t	2 db 20 m³-es rm.ac.tart. 2 db 10 " "	"E"	
5.	Üzemen kivül	-	Folyamatos mononitráló "C[illegible]B sav. üzem"		
6.	Benzótriflourid	10 t	2 db 5 m³-es ac.tartály	"C"	
7.	Hulladéksav	-	"üzemen kivül"		
8.	Hidrogén /Nyers/Benzitriflourid	5 Norm. m³ 1,5 t	Hidrogénező üzem technikai rendszerében.	"E"	
9.	Hidrogén	180 Norm.m³	Gazométerben	"A"	
10.	Hidrogén	30 db	Acélpalackba töltve	"A"	1 palack=50 Norm.m³
11.	3 Amino-benzotrifluorid	25 t	Technikai rendszerben	"A"	1640500 3. [illegible]

ATTACHMENT 2

l2.	Amino-benzotriflourid Benzótriflourid	50 t 40 t	2 db. 50 m^3-es [illegible] l db. " - " -	"	
l3.	Herbicidek (Aromatol)	40 t	3 db 25 m^3-es tartály	"B"	Olitreff kiszerelő
l4.	Cseppfolyós Nitrogén	8 t	5 bar. nyomás alatt tárolva	"A"	"N2 tárolvó "
l5.	Propionsav Foszfor-triklorid Metanol KPS Toluol Butil-aldvel	5 t 3 t 4 t 3 t 3 t 3 t	Az üzem technikai rendszerében.	"A"	
l6.	Olajraktár	40 dbt	Zárt hordokban(200 lit)	"A"	
l7.	Aro-izó-butiró-nitril	3 t	Zárt raktár (papirdobokban)	"A"	
l8.	Regenerált izóbutil-alkohol	20 m^3	30 m^3-es ac.tartály (kármentő)	"B"	
l9.	Klórszufornsav	8 t	25 m^3-as ac. tartály	"C"	Vizzel nem érintkezhet robbanásszerü hevességgel bomlik
20.	Klórpropionsav-metilészter	l0 t	Müag.béléses 200 l-eshordó		
2l.	Metanol	20 t	20 m^3-es fedett ac.tart.	"A"	
22.	Max 50 % vizes Metanol Kloroform	l00 m^3 l00 m^3	l db l50 m^3 -es tartály l db. " "	"E"	

- 3 -

Sorszám:	Veszélyes anyag megnevezése:	Mennyisége:	Tárolás módja:	Tűzv. Fok.	Megjegyzés:
23.	Metanol Toluol Xilol Ciklóhexanon	20 t 30 t 15 t 10 t	9 db 20 m^3-as acéltartály Nyitott süllyesztett tároló tartályok "Szezontol függően működik"	"A" "B"	
24.	Aromatol	100 t	2 db 300 m^3-as ac.tartály	"B"	
25.	Propionsav	25 t	2 db 25 m^3-es Alu.tartály	"B"	
26.	Sósav	50 t	3 db 50 m^3-es poliészter tartály 1 db 16 " koroset tart. 1 db.25 " " "	--	
27.	Xilol	47 t	1 db. 200 m^3-es ac.tart.	"A"	
28.	Higany Marónátron lúg NaOH Kénsav H_2SO_4	37,7 t 25 t 6 t	Technológiai rendszerben 3 db 20 m^3-es ac.tartály 1 db 5 " - " -	"E"	
29.	Higany Maronátron lúg	28 t 15 t	Technológiai rendszerben 2 db 20 m^3-es ác.tartály	"E"	
30	Hidrogén	50 Norm M^3	1 db 50 m^3-as gazométer	"A"	
31.	Kénsav	90 t	4 db 25 m^3-as álló ac.tart.	"E"	
32.	Kénsav 70 %	40 t	2 db 25 m^3-as fekvő ac.t.	"E"	

C2: ATTACHMENT 2

Sorszám:	Veszélyes anyag megnevezése:	Mennyisége:	Tárolás módja:	Tűzv. Fok.	Megjegyzés:
33.	Csepf. klór	50 t	4 db 25 m^3-as ac.tartály		

C2: AT

	- " - (Időszakosan) ~ intermittent	60 t	Vasuti tartály kocsiban in rail tank car.		
35.	Hypó (gyártás)	22 t	3 db 20 m^3-as titántart.		
36.	Sósav (gyártás) production	35 t	6 db 10 m^3-as Müag.tartály		
37.	Sósav (rampa) st ramp	450 t	6 db 150 m^3-as poliészter tartály		
38.	Hypó (rampa)	180 t	4 db 50 m^3-as betonbélésü acéltartály 2 db 50 m^3-as poliészter tartály		
39.	Hidrogénperoxid 70 %-os — " — — " —	15 t 1,7 t 5 t	2 db 20 m^3-as Müag.tartály 2 db 1,7 m^3-es - " - 50 lit. Müag.balonban.		
40.	Maronátron lúg	200 t	2 db. 500 m^3 ac.tartály 1 db 200 m^3 - " -		

MENT 2

C2: ATTACHMENT 3

P&IDs AND KEYS FOR PRODUCTION, STORAGE AND SHIPMENT OF CHLORINE AT BVM

Translated Titles

1 New cell room, ventilators and emergency neutralisation.

2 Old cell room and auxiliary fans.

3 Extraction system to hypo plant.

4 Chlorine washing with water and cooling.

5 Chlorine drying by sulphuric acid.

6 Sulphuric acid plant.

7 Chlorine compressing and filtering.

8 Chlorine condensation.

9 Chlorine evaporation and distribution.

10 Chlorine storage.

11 Chlorine shipment in railcars, crums and cylinders.

12 Padding pressure air supply.

13 Hypo plant.

14 HCl plant.

C2: ATTACHMENT 3

P&IDs AND KEYS FOR PRODUCTION, STORAGE AND SHIPMENT OF CHLORINE AT BVM

Translated Titles

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8 Chlorine condensation.

9 Chlorine evaporation and distribution.

10 Chlorine storage.

11 Chlorine shipment in railcars, drums and cylinders.

12 Padding pressure air supply.

13 Hypo plant.

14 HCl plant.

Csatlakozási pontok és kapcsolt folyamatábrák

számozása, megnevezése.

Folyamatárák megnevezése, számozása.

1.	sz. Folyamatábra	Uj cellatermi klórvonal, ventillátorház vészsemmisitése.
2.	sz. Folyamatábra	Régi cellatermi klórvonal, tisztitó rekesz megszivás.
3.	sz. Folyamatábra	Sólé kifuvatás, Hipó üzem szivása alatt álló klórtartalmu gázvezetékek kapcsolása.
4.	sz. Folyamatábra	Klórgáz vizes mosása, hütése.
5.	sz. Folyamatábra	Kénsavas klórszáritás.
6.	sz. Folyamatábra	Kénsavfejtés, tárolás, elosztás.
7.	sz. Folyamatábra	Klórgáz süritése, szürése.
8.	sz. Folyamatábra	Klór cseppfolyósitás.
9.	sz. Folyamatábra	Klór elosztás elpárologtatás, abgáz, vezetékek kapcsolása.
10.	sz. Folyamatábra	Cseppfolyós klór tárolása.
11.	sz. Folyamatábra	Cseppfolyós klór töltése tartálykocsiba, hordóba, palackba.
12.	sz. Folyamatábra	Levegőállomás.
13.	sz. Folyamatábra	Hipó üzem, klórmegsemmitités.
14.	sz. Folyamatábra	Sósav üzemi klórvonal

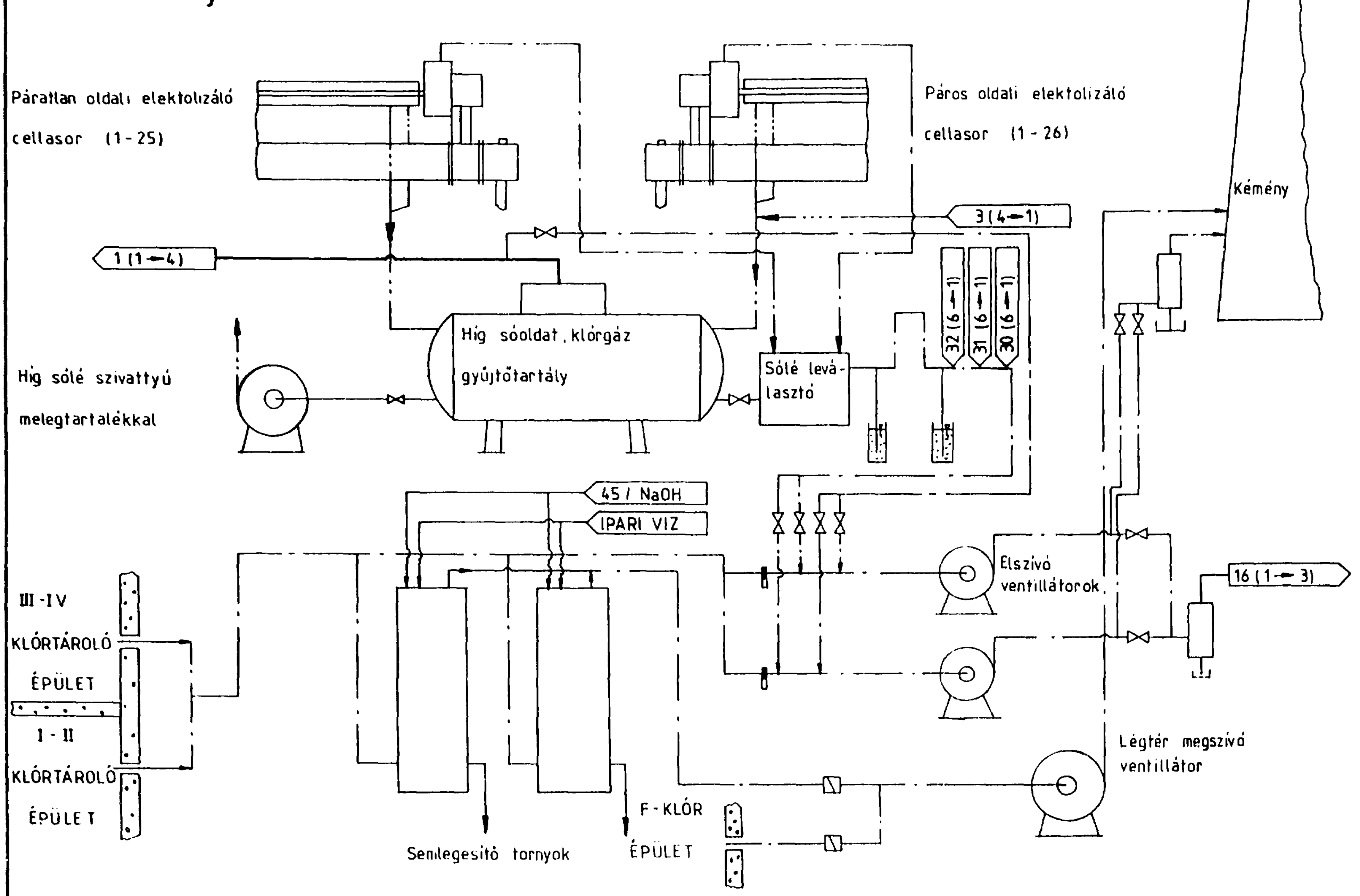
Csatlakozási pontok megnevezése, számozása:

```
                 I---------------------------------------------\
Jelölési mód:    I  Csatlakoz.pont (foly.ábra -> foly.ábra)  >
                 I---------------------------------------------/
```

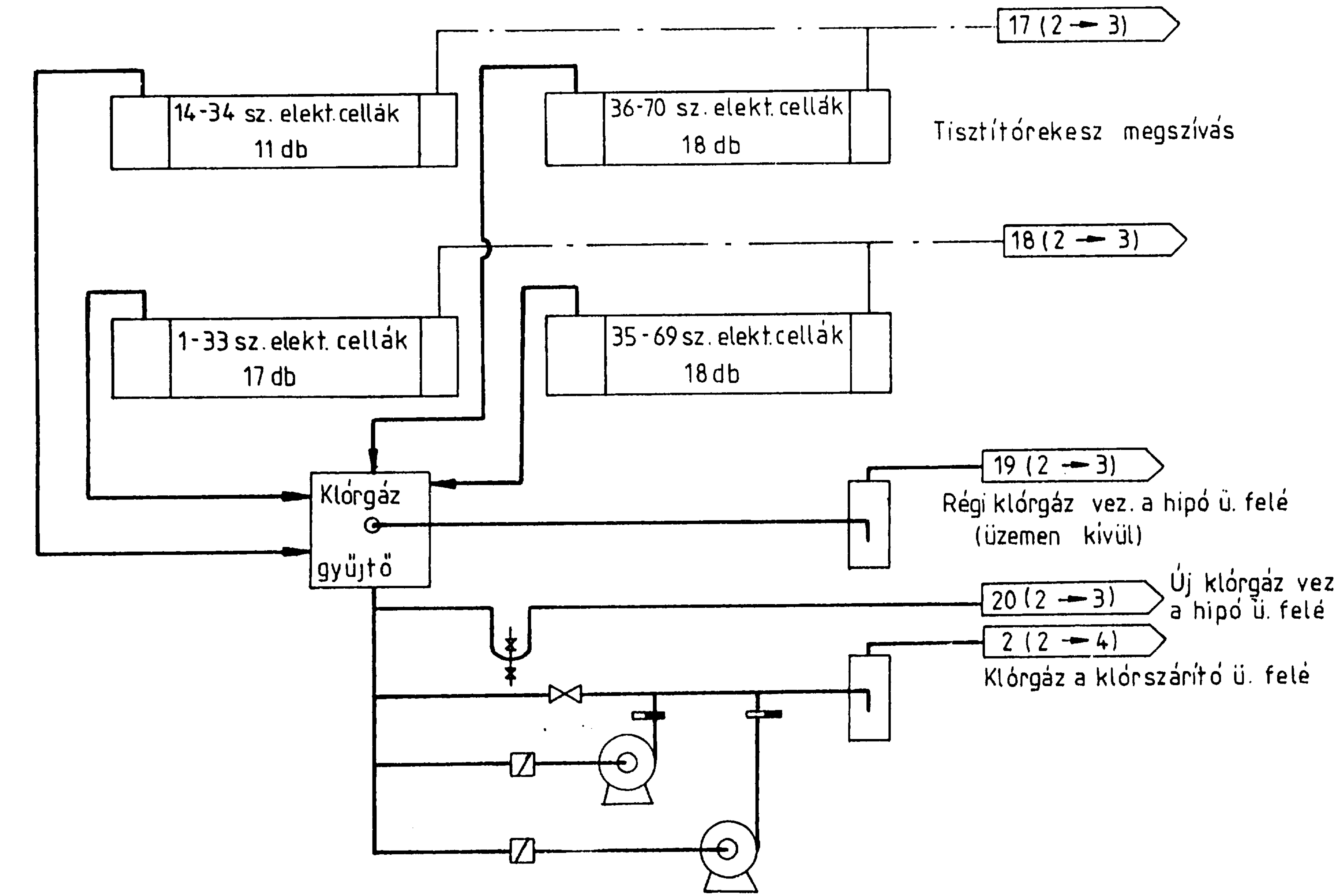
1. (1 -> 4) Klórgáz uj cellateremből a mosótornyokhoz.
2. (2 -> 4) Klórgáz régi cellatermből a mosótornyokhoz.
3. (4 -> 1) Klóros viz szaporulat az uj cellatermi jobb oldali (páros) híg sólé vezetékbe.
4. (4 -> 1) Titán hütök elfolyó hütövize az uj cellatermi hidrogénhütökhöz.
5. (4 -> 5) Klórgáz I. mosótoronytól I. turbószáritóig.
6. (4 -> 5) Klórgáz II. mosótoronytól II. turbószáritóig.
7. (6 -> 5) A Kénsav a tárolóparktól a klórszáritó üzemi napi tartályig.
8. (5 -> 6) Klórszáritó üzemi cc. kénsav napi tartály tulfolyó vezetéke a IV. cc. kénsav tárolóhoz.
9. (5 -> 7) Száritott klór a klórszáritó üzemtöl a klórkompresszorokhoz.
10. (5 -> 6) Híg kénsav a klórszáritó üzemi gyüjtötartálytól a híg kénsav tárolókhoz.
11. (7 -> 6) Klóros kénsav a klórkompresszoroktól a híg kénsav tárolókhoz.
12. (6 -> 7) cc. kénsav a tárolóparktól az F.klór üzemi napi tartályhoz.

13. (7 -> 6) F.klór üzemi napi tartály túlfolyó a IV. cc. kénsav tárolóhoz.
14. (7 -> 8) Komprimált, szürt klórgáz a cseppfolyósitókhoz.
15. (7 -> 9) Komprimált, szürt klórgáz az elosztó szelepfalhoz.
16. (1 -> 3) UT.-F.klór ventillátor házból a hipó üzem felé.
17. (2 -> 3) RT. bal oldali tisztitó rekesz megszivás.
18. (2 -> 3) RT. jobb oldali tisztitó rekesz megszivás.
19. (2 -> 3) RT. klór gyüjtötöl a hipó üzem felé (régi közvetlen klór vezeték) hig sólé tartály légzöinek megszívása.
20. (2 -> 3) RT. közvetlen klórvezeték hipó üzem felé (uj) alacsony terhelésnél.
21. (11-> 3) Klórfejtés abgázvezetéke.
22. (9 -> 3) F.klór üzem abgázvezetéke.
23. (3 ->13) Hipó üzem szivása alatt álló abgáz vezetékrendszer csatlakozása a hipó tornyokhoz.
24. (14-> 3) Sósav üzemi abgáz- és lefuvató vezeték a Hipo üzem felé.
25. (11-> 7) Vagontöltö elosztó csatlakozása a klórkompresszorok szivó ágához.
26. (10-> 7) I-II. tárolók vészmegszivás (Ideiglenesen dinamikus nyomáskiegyenlítö is.
27. (10-> 7) Dinamikus kiegyenlitö csatlakozás (nem üzemel)
28. (10-> 7) III-IV. tároló vészmegszivás (ideiglenesen dinamikus nyomáskiegyenlitö is)
29. (7 -> 9) Süritett klór vezeték lefuvatás a hipó üzem felé. (nincs üzembe helyezve)
30. (6 -> 1) Híg kénsavas vagon légtér megszivás.
31. (6 -> 1) I. híg kénsav tároló légtér megszivás.
32. (6 -> 1) II. hig kénsav tároló légtér megszivás.
33. (10-> 9) Uszószabályozó légtérmegszivás.
34. (10-> 9) I-II. klórtároló hasadótárcsáinak, biztonsági szelepeinek lefúvatása
35. (10-> 9) III-IV. klórtároló hasadótárcsáinak, biztonsági szelepeinek lefúvatása
36. (10-> 9) Vagontöltövezeték csatlakozása az elpárologtató elosztóhoz.
37. (10-> 9) I-II. klórtároló elpárologtató vezeték csatlakozása az elpárologtató elosztóhoz.
38. (10-> 9) III-IV. klórtároló elpárologtató vezeték csatlakozása az elpárologtató elosztóhoz.
39. (8 ->14) Abgáz vezeték az F.Klór üzemi rotamétertöl a sósav üzembe.
40. (10->11) F.klór a klórfejtéshez, a III-IV. klórtárolótól.
41. (10->11) Vagontöltö vezeték csatlakozása a vagontöltö elosztóhoz.
42. (12->10) Préslevegö alevegöállomástól az F.klór üzemi klórtárolókhoz.
43. (12->11) Préslevegö a hordótöltöhöz.
44. (12->11) Préslevegö a vagontöltö elosztóhoz.
45. (8 -> 9) Cseppfolyósitási véggáz és I-II.klórtárolók abgázvezetékének csatlakozása az F.klór üzemi abgáz gyüjtövezetékbe.
46. (8 -> 9) Cseppfolyós klór a cseppfolyósitóktól az úszószabályozóhoz
47. (10-> 8) I-II. klórtárolók abgázvezetékének csatlakozása
48. (10-> 9) III-IV. klórtárolók abgázvezetékének csatlakozása
49. (9 ->14) Komprimált klór az F.Klór üzemi elosztótól a sósav üzembe.

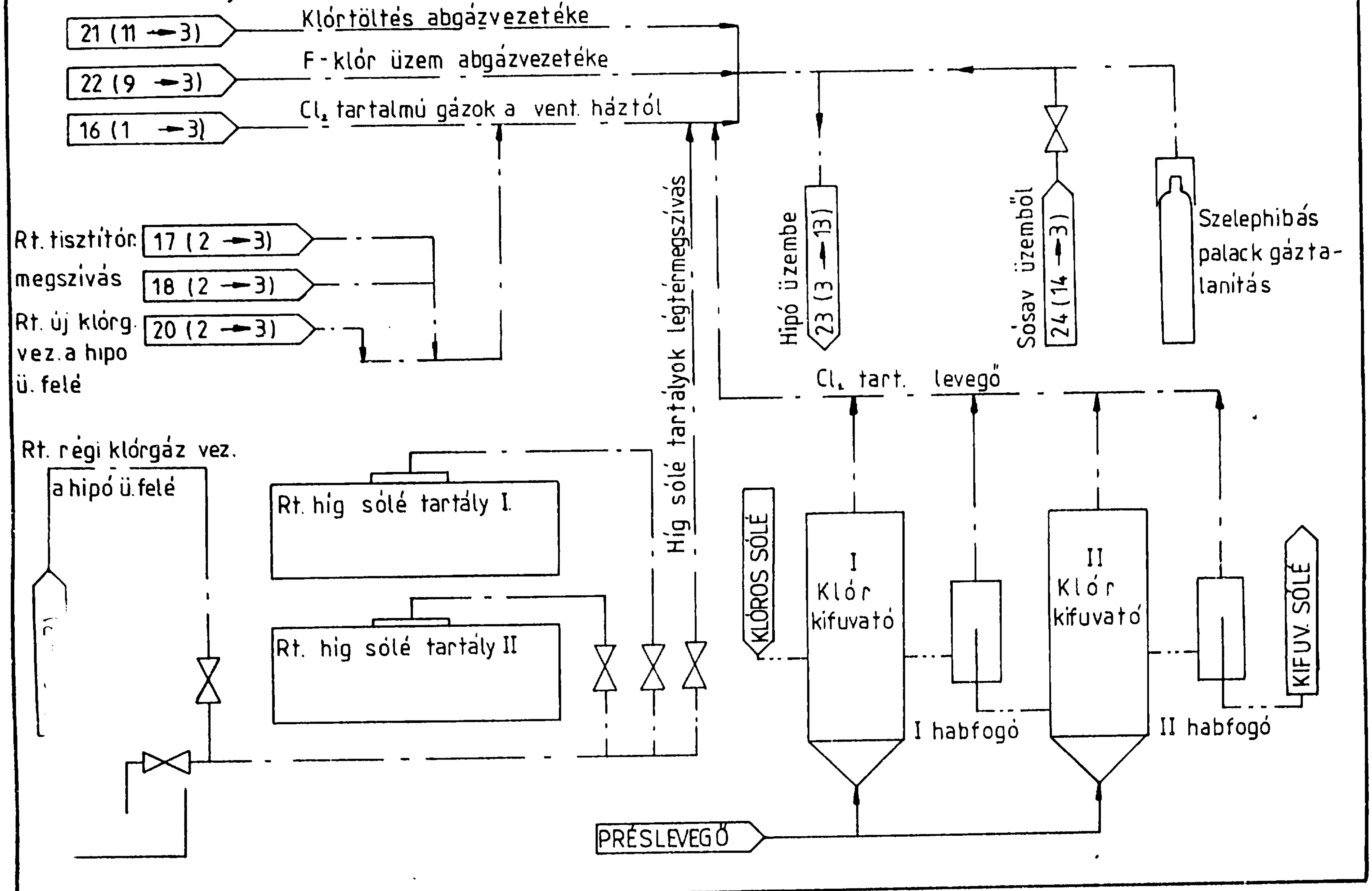
1 sz. folyamarábra



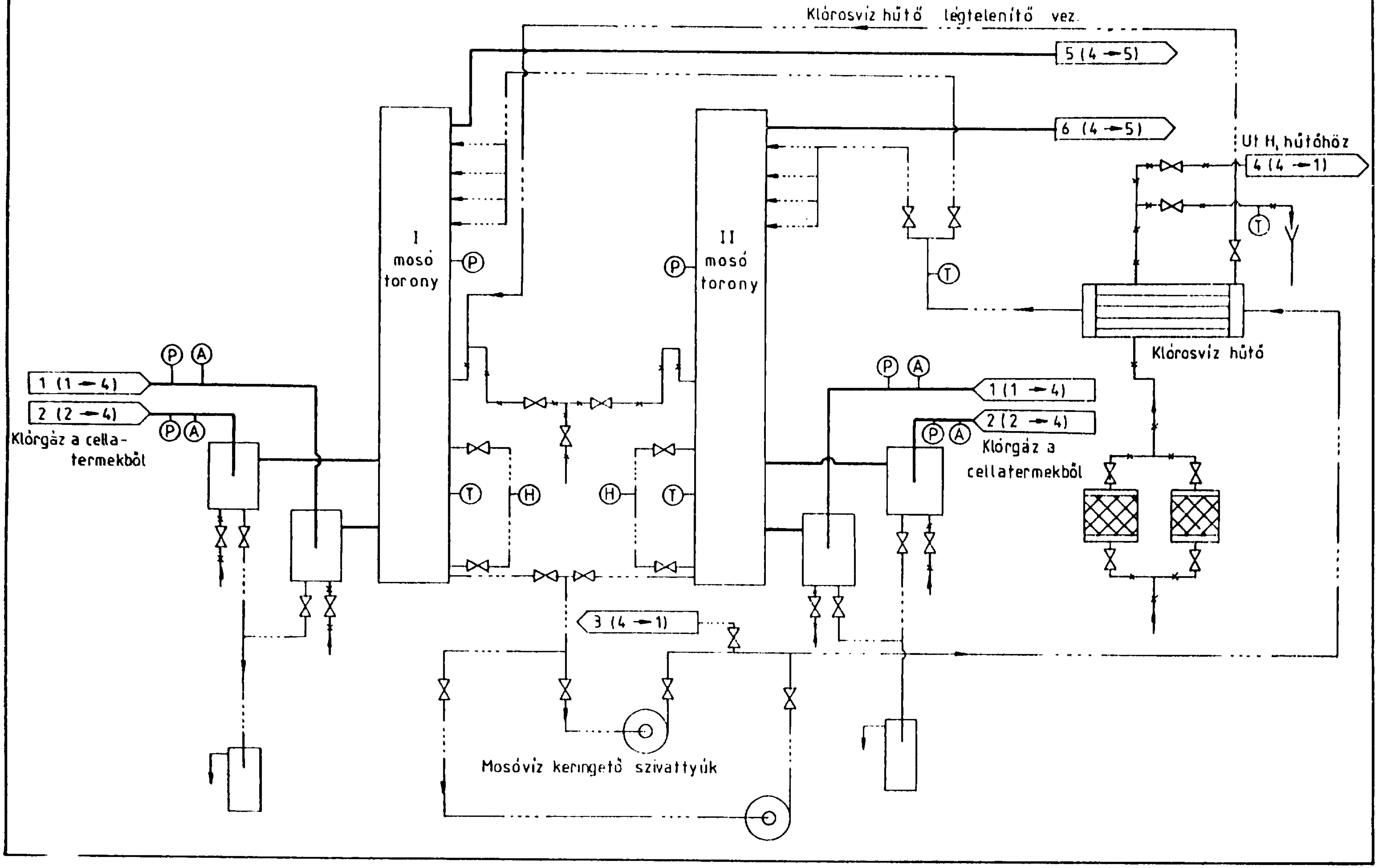
2 sz. folyamatábra



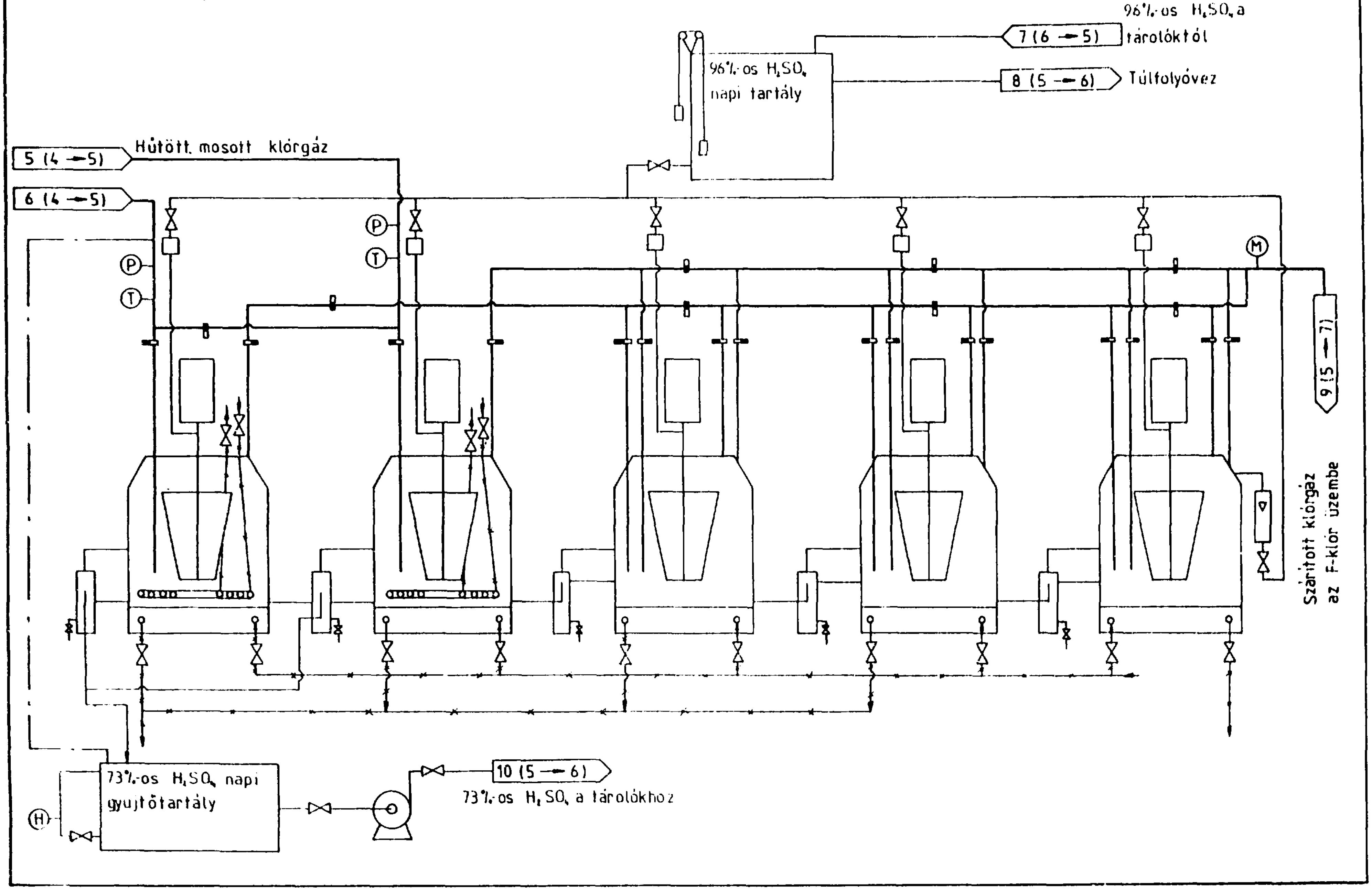
3 sz. folyamatábra



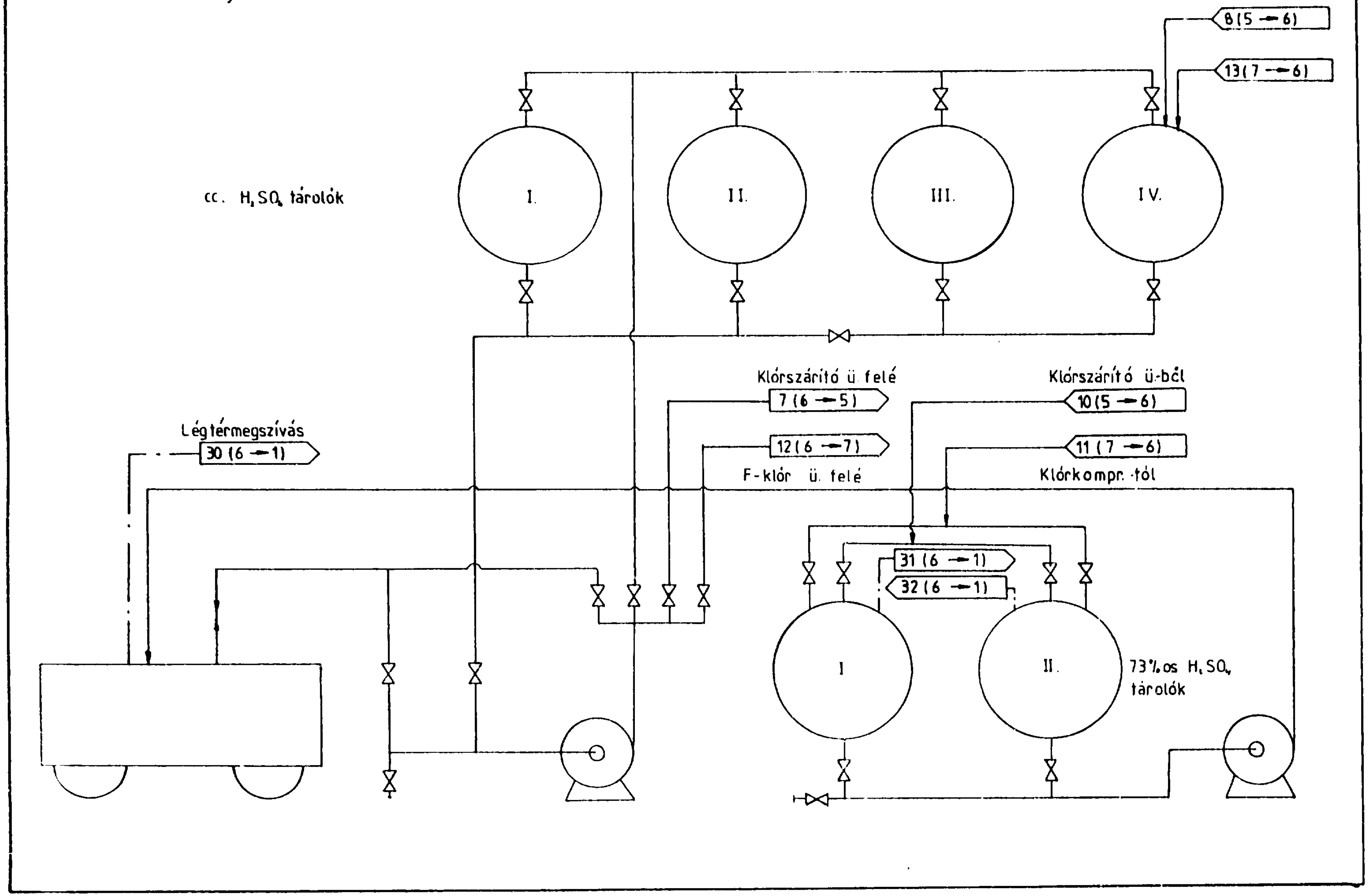
4 sz folyamatábra



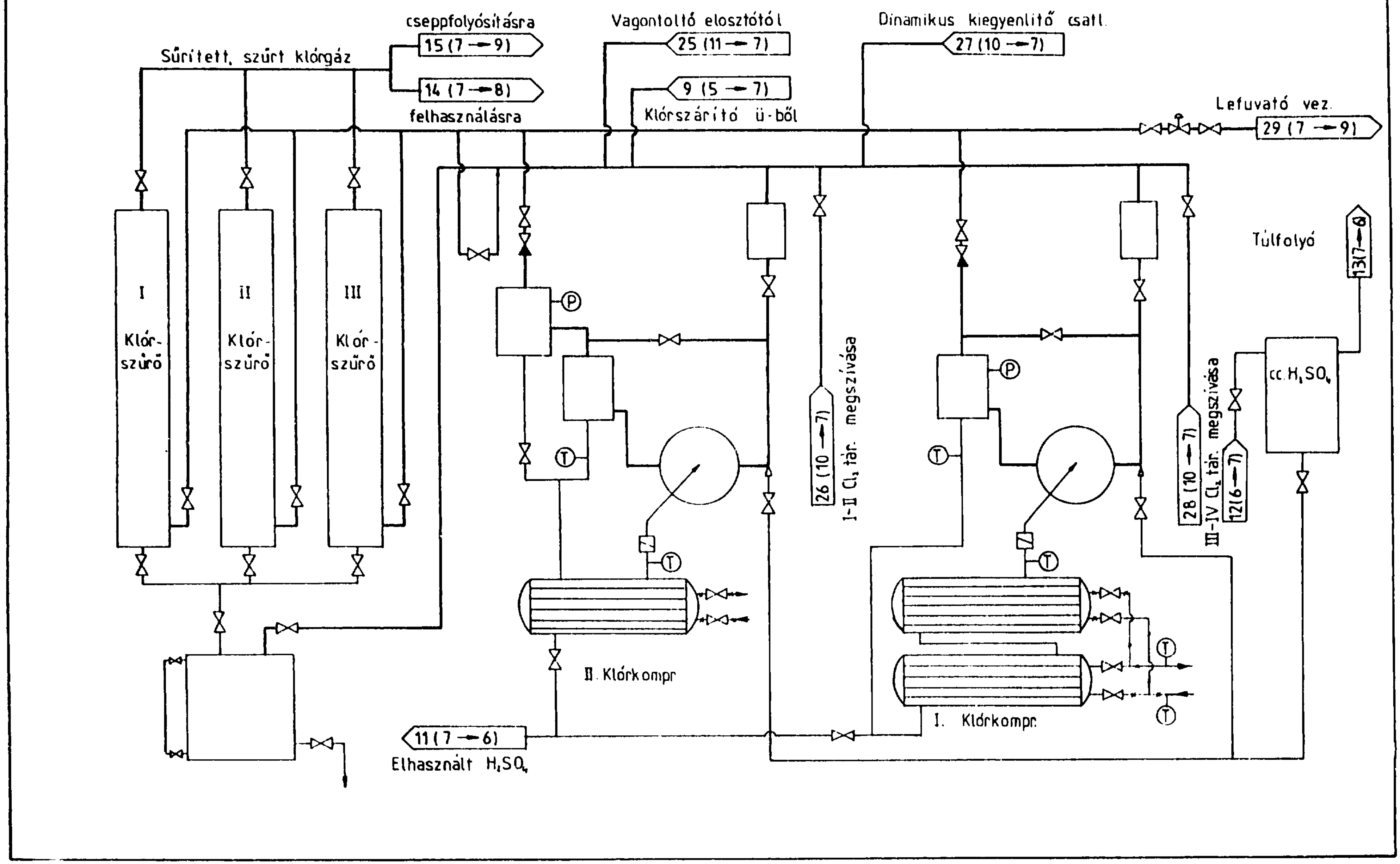
5 sz. folyamatábra



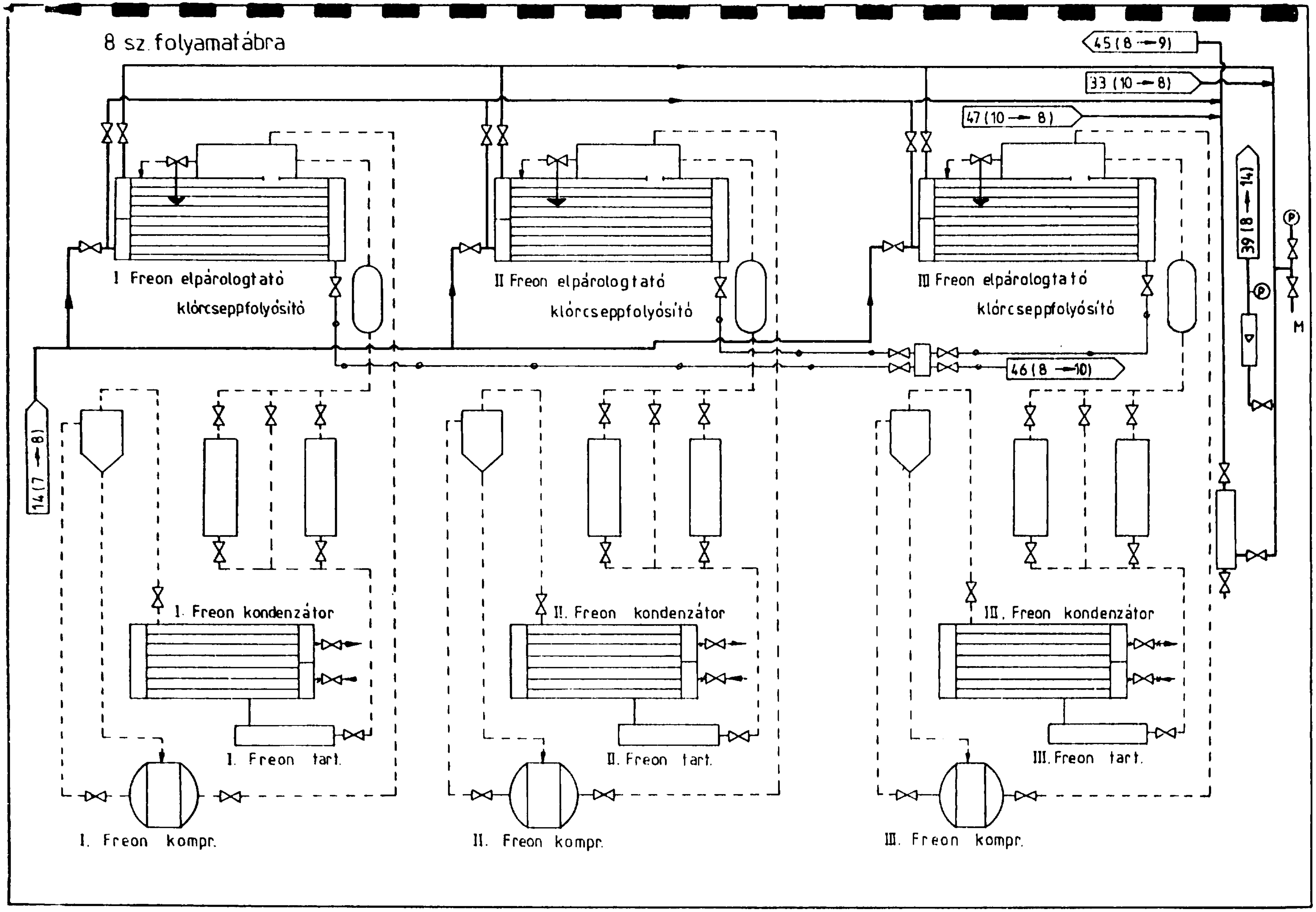
6 sz folyamatábra



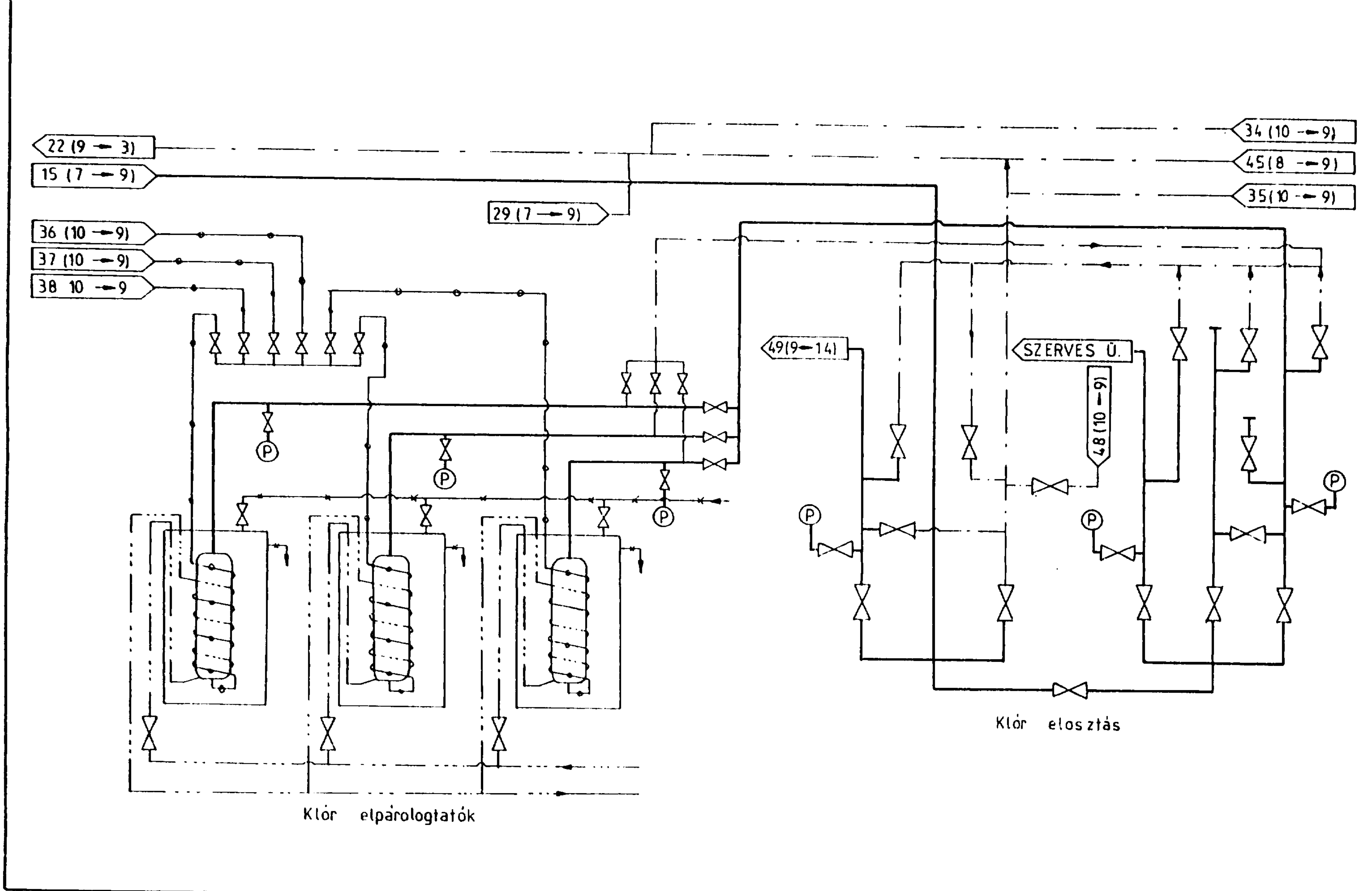
7 sz. folyamatábra

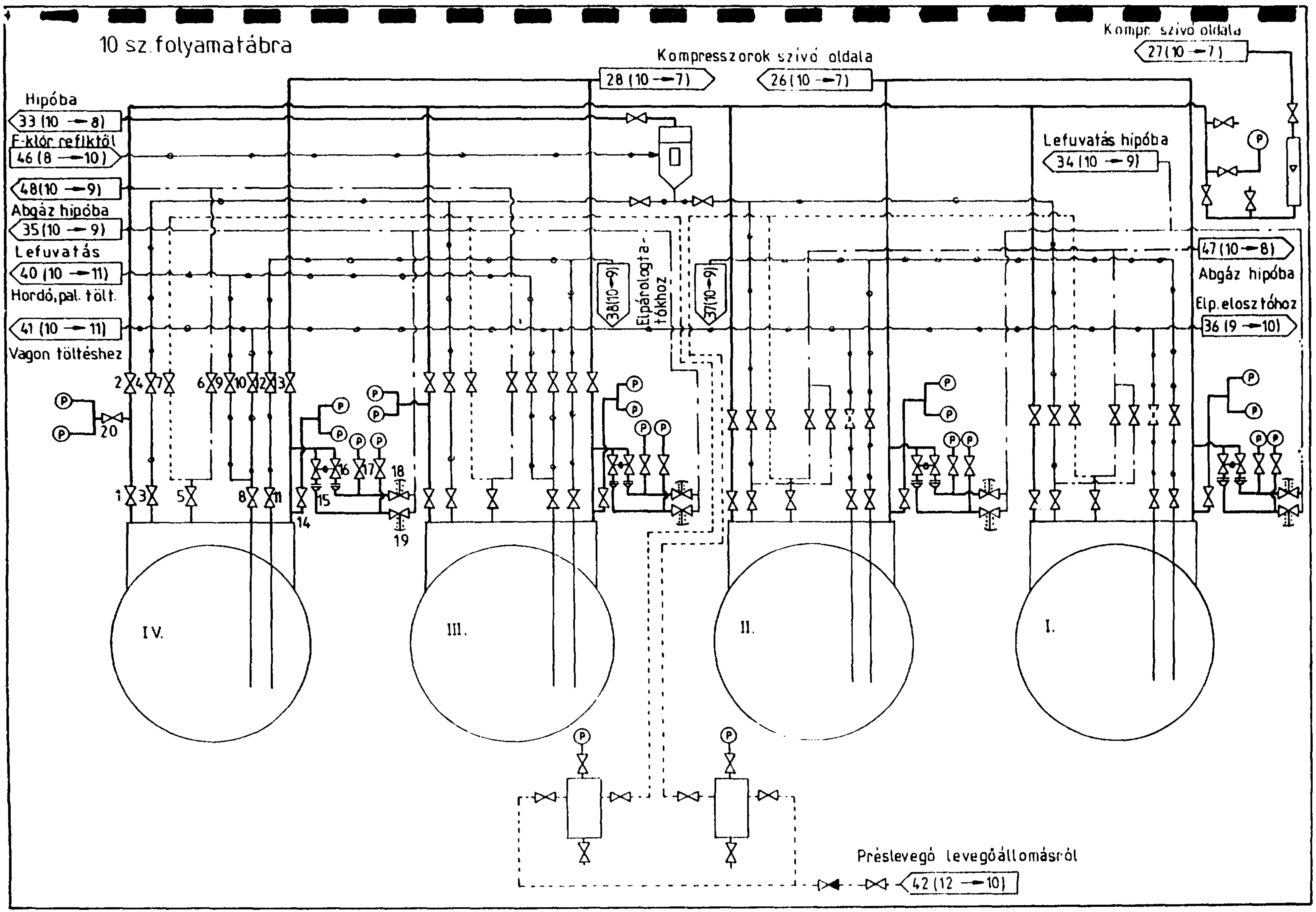


8 sz. folyamatábra

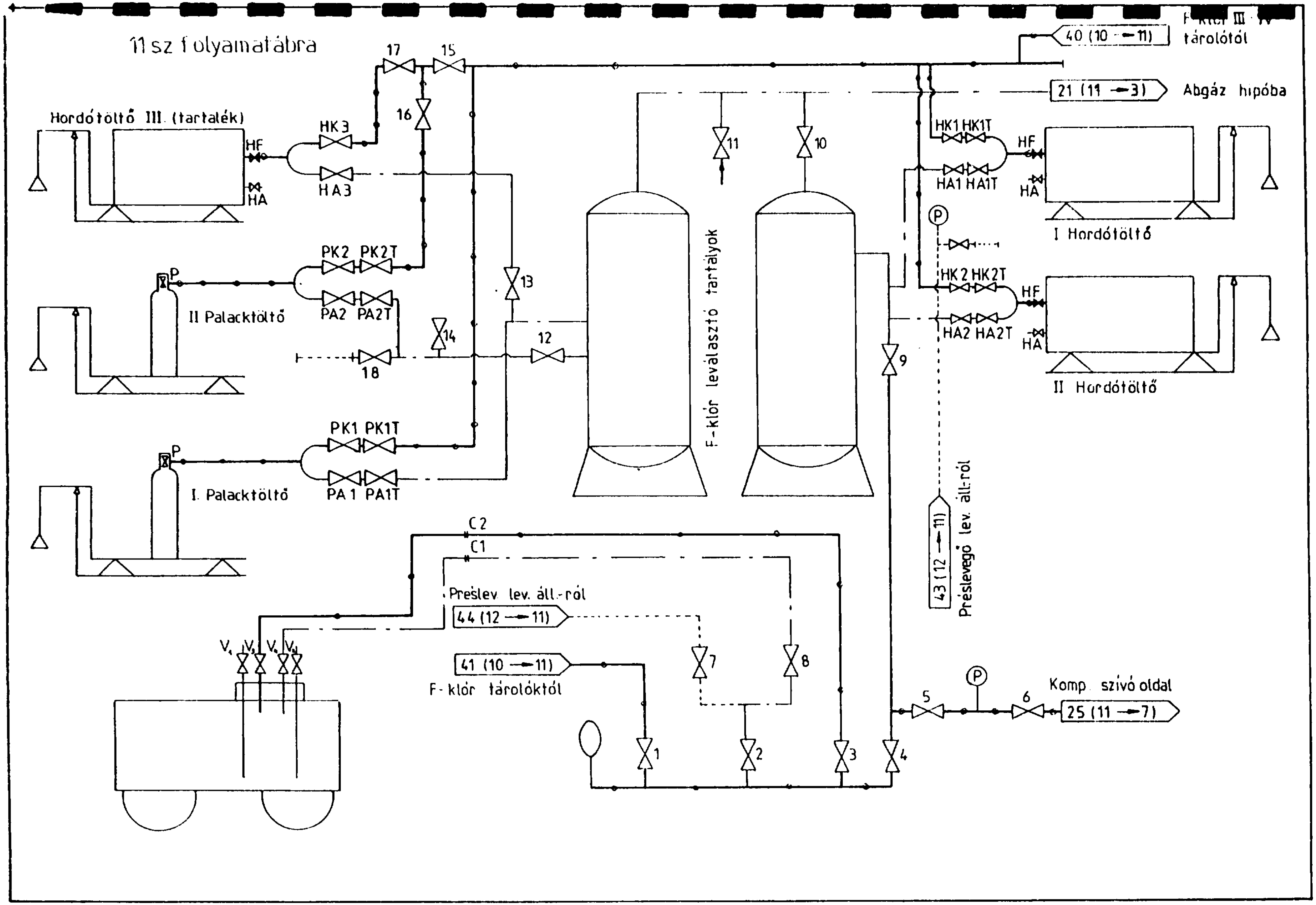


9 sz folyamatabra

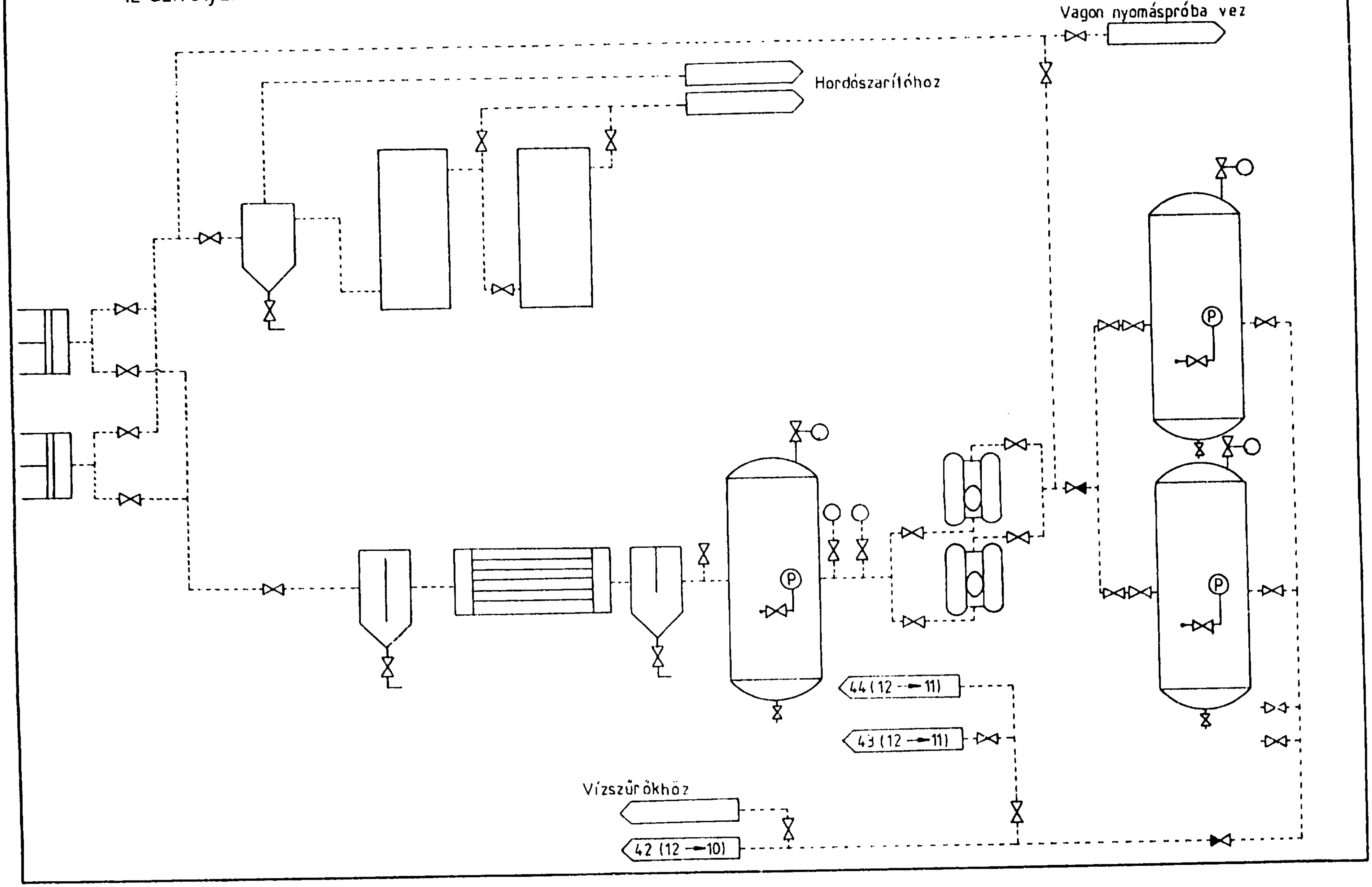




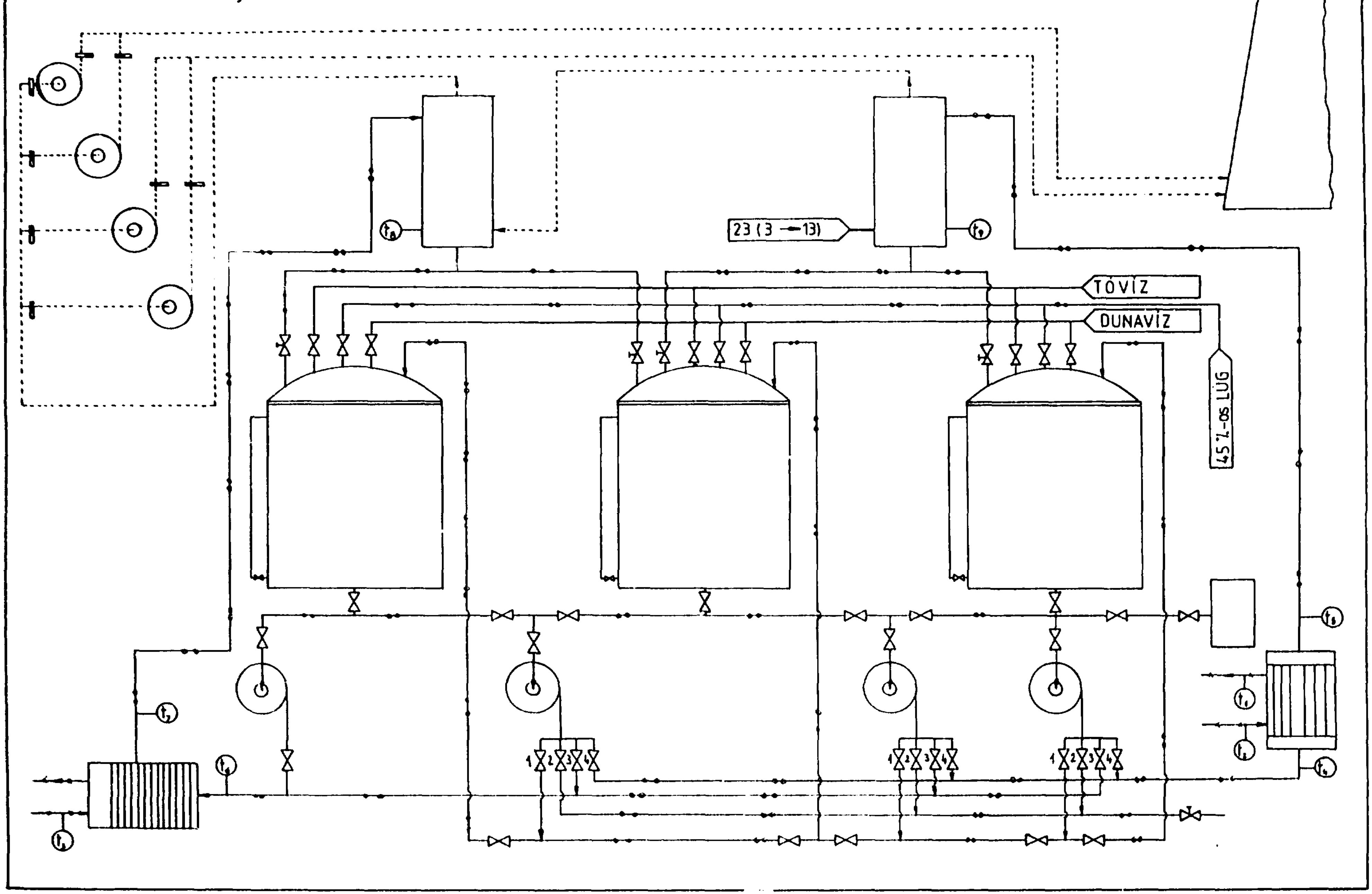
10 sz. folyamatábra
Kompresszorok szívó oldala
28 (10 → 7)
26 (10 → 7)
Kompr. szívó oldala
27 (10 → 7)
Hipóba
33 (10 → 8)
F-klór refiktől
46 (8 → 10)
48 (10 → 9)
Abgáz hipóba
35 (10 → 9)
Lefuvatás
40 (10 → 11)
Hordó, pal. tölt.
41 (10 → 11)
Vagon töltéshez
Lefuvatás hipóba
34 (10 → 9)
47 (10 → 8)
Abgáz hipóba
Elp. elosztóhoz
36 (9 → 10)
38 (10 → 9)
Elpárologtatókhoz
37 (10 → 9)
IV.
III.
II.
I.
Préslevegő levegőállomásról
42 (12 → 10)


11 sz folyamatábra
40 (10 → 11)
tárolótól
21 (11 → 3)
Abgáz hipóba
Hordótöltő III. (tartalék)
HK3
HA3
HF
HA
17
15
16
11
10
HK1 HK1T
HA1 HA1T
I Hordótöltő
HK2 HK2T
HA2 HA2T
II Hordótöltő
PK2 PK2T
PA2 PA2T
II Palacktöltő
13
14
18
12
F-klór leválasztó tartályok
9
PK1 PK1T
PA1 PA1T
I. Palacktöltő
P
C2
C1
Préslev. lev. áll.-ról
44 (12 → 11)
41 (10 → 11)
F-klór tárolóktól
43 (12 → 11)
Préslevegő lev. áll.-ról
7
8
1
2
3
4
5
6
Komp. szívó oldal
25 (11 → 7)

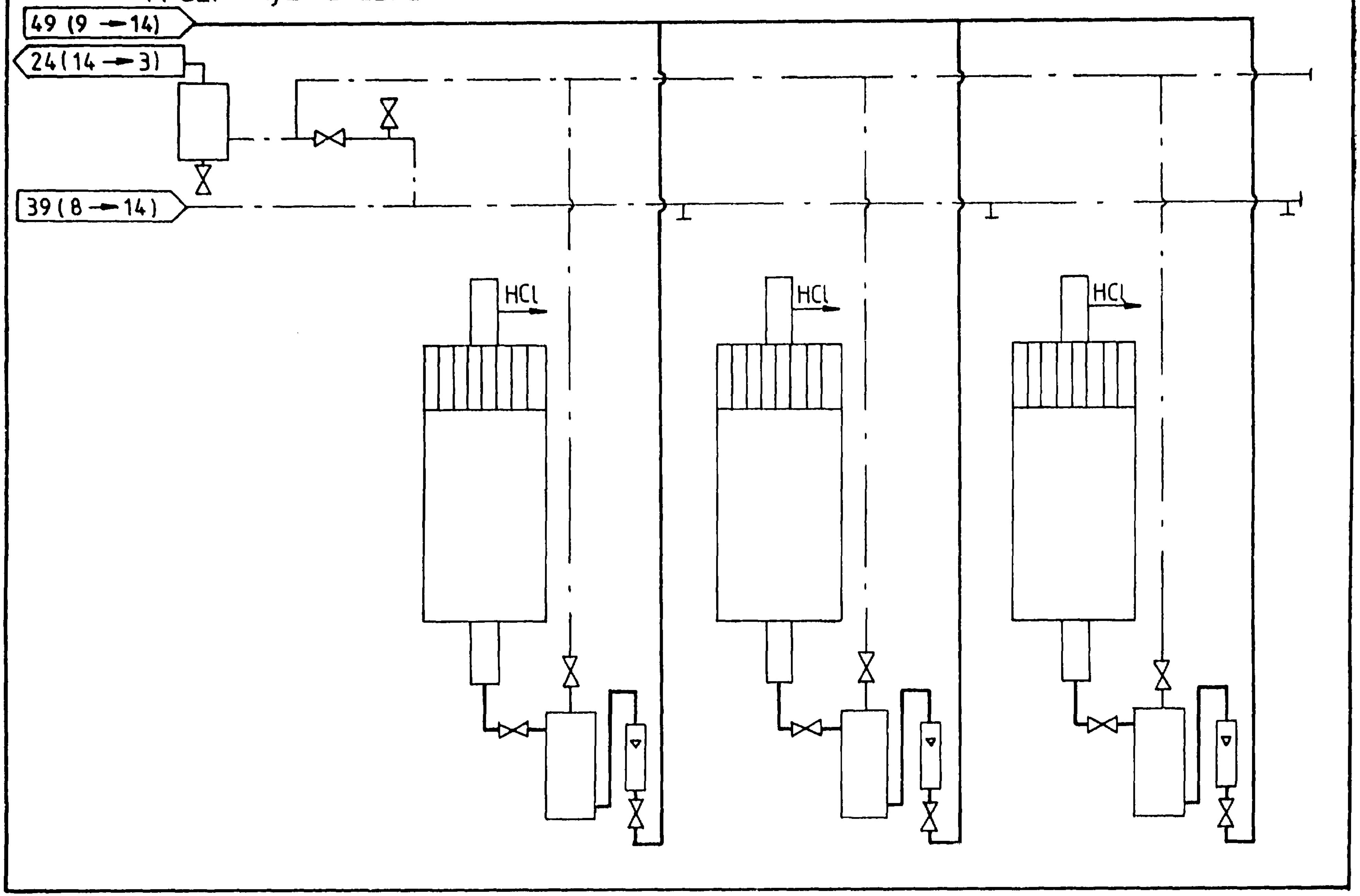
12 sz. folyamatábra

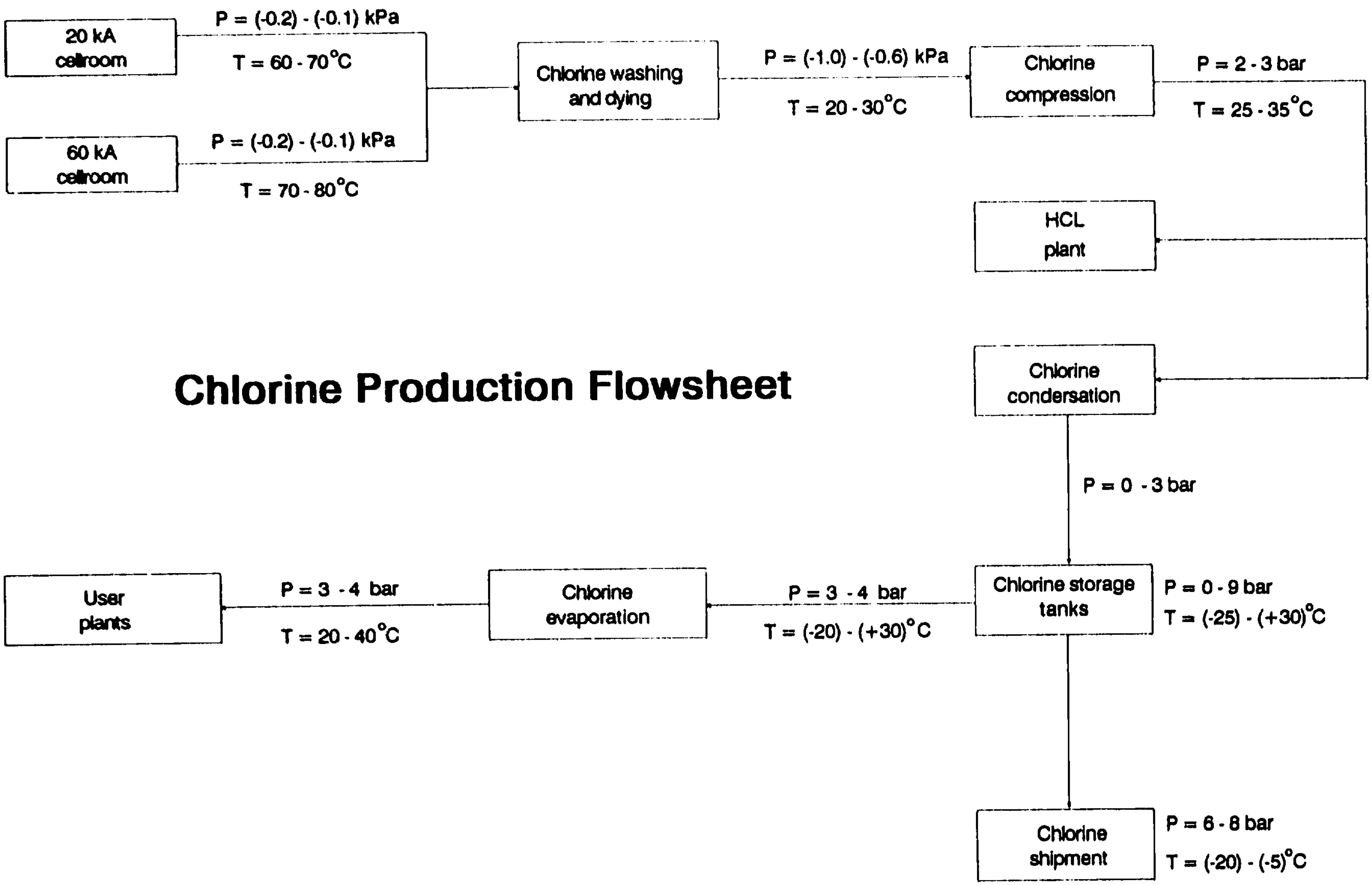


13 sz. folyamatábra



14 sz. folyamatábra





Chlorine Production Flowsheet

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			H
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

List of C3 Forms Attached

No	Incident	Classification	Comment
1	*Liquid chlorine release*	*9 March 1988*	*Inadequate work systems and operator error*
2	*Chlorine release*	*26 September 1988*	*Equipment failure and operator error*
3	*HCl release*	*20 September 1989*	*Equipment failure*
4	*Chlorine produced in reaction*	*31 December 1989*	*Operator error*
5	*Chlorine release*	*31 January 1990*	*Equipment failure and operator error*
6	*Liquid chlorine release*	*5 November 1990*	*Operator error*
7	*Cylinder explosion*	*14 November 1990*	*Operator error*
8	*Chlorine inhalation*	*10 June 1991*	*Inexperienced worker*
9	*Chlorine inhalation*	*24 August 1992*	*Operator error*

Revision History

Date	Issue	Comments
16/2/93	1	First issue prepared by SRD

Prepared by: B Blackburn	Signature: [signature]	Date: 1/3/93.

OUTLINE SAFETY DOCUMENT	C3
INSTALLATION HISTORY	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	H

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Nature of the history investigation

The plant history was investigated by examining the incident records from the BVM Electrolysis Workshop for the years 1988-92 inclusive. The forms searched are called "Occupational Accident Report Forms" which are required to be completed as a result of regulations brought into force in 1987. The search was restricted to the chlorine plant, and as a result did not include the report of the explosion in the organics plant in January 1992.

Brief descriptions of the events occurring during the five year period are given.

Further investigation - of incidents in other areas of the site, or of reliability issues was not undertaken.

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
EVENT: Liquid Chlorine Release, 9 March 1988			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *9 March 1988*

Description of incident:

Insufficient oxygen in breathing apparatus. HCl plant.

Pipework opened for repair of leak was not empty of chlorine, including significant liquid chlorine, because distant organics plant had not notified electrolysis plant when they turned off valve. Chlorine breakthrough from boiling in the hypochlorite plant plus further pipe fracture caused by cold liquid chlorine in HCl plant led to further loss of chlorine.

Cause of incident:

Poor communications between plants; poor procedure prior to maintenance.

Type and category of incident:

Operator error / loss of containment / personal injury.

Potential safety implications (on- and off-site):

Serious injuries on site.

Potential environmental implications:

Minor

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
EVENT: Liquid Chlorine Release, 9 March 1988			

Action taken:

1 *Tighten procedures (communications among plants).*
2 *Notify protective equipment maintenance firm re fault.*
3 *Wider availability of PPE through plant.*

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 2	ISSUE: 1	DATE: 16/2/93	
EVENT: Chlorine Release, 26 September 1988			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *26 September 1988*

Description of incident:

Chlorine compressor cut out. As a result chlorine leaked into cell room. Injured party donned gas mask and off-gassed to hypochlorite plant. While opening valve, the man inhaled chlorine, despite mask (unfamiliarity with mask).

It is not clear if the cells shut down automatically as intended

Cause of incident:

Chlorine compressor had no back-up power. Man unfamiliar with gas mask.

Type and category of incident:

Plant failure/loss of containment/personal injury.

Potential safety implications (on- and off-site):

Possible serious injury to workers.

Potential environmental implications:

None

Action taken:

1 *Backup generator on order*
2 *Further training/drill in use of gas masks.*

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 3	ISSUE: 1	DATE: 16/2/93	
EVENT: HCl Release, 20 September 1989			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *20 September 1989*

Description of incident:

HCl storage tank split, complete contents of 10 m^3 33% HCl spilled. No injuries.

Cause of incident:

Material failure (fatigue in stiffening member).

Type and category of incident:

Loss of containment.

Potential safety implications (on- and off-site):

Serious hazard to employees from HCl release.

Potential environmental implications:

Possible discharge into drains system causing pollution

Action taken:

Tank repaired

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 4	ISSUE: 1	DATE: 16/2/93	
EVENT: Chlorine Produced in Reaction, 31 December 1989			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *31 December 1989*

Description of incident:

Hypo drained into line containing acid (from earlier planned release from Organic "B" plant) leading to chlorine evolution. The release should have gone into alkaline drain.

Cause of incident:

Operator error.

Type and category of incident:

Unintended chemical reaction/toxic gas evolution.

Potential safety implications (on- and off-site):

Danger to site personnei from chlorine.

Potential environmental implications:

None

Action taken:

1 *Hypochlorite storage/buffer capacity increased.*
2 *Improvement of drain line control system.*

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 5	ISSUE: 1	DATE: 16/2/93	
EVENT: Chlorine Release, 31 January 1990			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *31 January 1990*

Description of incident:

Liquid chlorine from a filling point was routed via the off-gas line into the old cell-room. One worker inhaled before putting on mask.

Cause of incident:

Faulty valve.

Type and category of incident:

Equipment failure / toxic gas / personal injury

Potential safety implications (on- and off-site):

Danger to site personnel from chlorine.

Potential environmental implications:

Minor

Action taken:

Valve replaced

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 6	ISSUE: 1	DATE: 16/2/93	
EVENT: Liquid Chlorine Release, 5 November 1990			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *5 November 1990*

Description of incident:

Following an operation by the previous shift to purge the railcar loading manifold, several valves had been left in an incorrect configuration and a blanking plate insufficiently secured. This was not checked by the next shift prior to a tank transfer operation and consequently there was a liquid chlorine leak from the railcar loading point, and liquid chlorine was drawn to the compressor. This led to loss of suction and chlorine release in the cell rooms as well. Two workers were hospitalised for 48 hours.

Cause of incident:

Coincidental errors by 2 operators - incorrect procedure: failure to check valve settings. Impact aggravated by failure to don gas masks - out of reach. Relatively inexperienced operators. This was exacerbated by complex plant and safety systems not designed for this type of incident.

Type and category of incident:

Operator errors/loss of containment/inhalation of toxic gas/personal injury to workers.

Potential safety implications (on- and off-site):

Liquid chlorine release - potentially fatal near point of release (within tens of metres).

Potential environmental implications:

Minor

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: 6	ISSUE: 1	DATE: 16/2/93	
EVENT: Liquid Chlorine Release, 5 November 1990			

Action taken:

1 *Tutorial re incident for all staff of chlorine plant.*
2 *Correct procedure re-emphasised (as set down in operating instructions).*
3 *New procedure: changing shift during process, valve positioning to be recorded in shift log.*
4 *Three employees reprimanded.*

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 7	ISSUE: 1	DATE: 16/2/93	
EVENT: Cylinder Explosion, 14 November 1990			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *14 November 1990*

Description of incident:

Two chlorine cylinders, contaminated by off-site user's waste water, overheated. One exploded on a lorry off-site en route to safe disposal. Bottle flew 60 m. BVM employee did not check cylinder weight before filling with chlorine.

Cause of incident:

Incorrect installation by user (no buffer vessel between cylinder and water to be treated). User's day log unclear on cylinder weights, dates of change overs. There had been previous incidents of water in cylinders from this user, who had had warnings.

Type and category of incident:

Explosion/management failures/operator error.

Potential safety implications (on- and off-site):

Serious danger to site employees and the public. The incident caused a severe danger both from explosions (missile production etc) and of toxic release. On-site, the explosion could have caused further escalation.

Potential environmental implications:

Minor

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: 7	ISSUE: 1	DATE: 16/2/93	
EVENT: Cylinder Explosion, 14 November 1990			

Action taken:

1 *No chlorine to be sold to user until his set up complies with regulations/BVM instructions.*

2 *Filling operator reprimanded.*

3 *New procedure: tare checked on receipt of empty cylinder from customer. (However, we were told that procedures for non-empty cylinders depended on their contents being either chlorine or water.)*

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 8	ISSUE: 1	DATE: 16/2/93	
EVENT: Chlorine Inhalation, 10 June 1991			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *10 June 1991*

Description of incident:

Man inhaled chlorine through gas mask, correctly worn, while making adjustment to chlorine cell. Due to inexperienc-, adjustment took longer than planned.

Cause of incident:

Worker inexperienced (training/supervision/inadequacy of protective equipment?)

Type and category of incident:

Personal injury (management failure).

Potential safety implications (on- and off-site):

Personal

Potential environmental implications:

None

Action taken:

None

OUTLINE SAFETY DOCUMENT			C3
INSTALLATION HISTORY			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 9	ISSUE: 1	DATE: 16/2/93	
EVENT: Chlorine Inhalation, 24 August 1992			

Source: *BVM Electrolysis Workshop*

Date information collected: *19 January 1993*

Does documentation exist? *Yes*

Date or period of incident: *24 August 1992*

Description of incident:

Power failure to old cell room. Incoming brine displaced chlorine. Workforce donned masks and exited. Power returned. Man went in to check if all equipment functioning. Phone went, so he took off mask to answer it. Inhaled chlorine. Emergency power cut in as designed, but only coped with critical items. It is not meant to prevent localised chlorine releases.

Cause of incident:

Human error.

Type and category of incident:

Operator error/human injury.

Potential safety implications (on- and off-site):

Danger to operator.

Potential environmental implications:

None

Action taken:

Reinforcement of requirements to retain mask in place.

OUTLINE SAFETY DOCUMENT MANAGEMENT SYSTEM			D
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Organisation chart*			*2*	*Drawn up from information provided*

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: B Blackburn	Signature: [signature]	Date: 1/3/93

OUTLINE SAFETY DOCUMENT	D
MANAGEMENT SYSTEM	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	2

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Information relating to staffing

Provide an organisation chart for the management of the industrial activity:

Chart appended - Attachment 1

What are the arrangements for initiating on-site emergency plans?

A new Site Emergency Plan has been published (see C2) but is as yet untried. The site arrangements such as control rooms, communications and siren warning system are considered inadequate.

Initiation of the emergency alarm is through the site dispatcher office. The initial responsibility rests at the plant level.

No emergency exercise has been carried out since 1986/1987.

What are the arrangements for initiating off-site emergency plans?

The emergency plan requires local authorities to be alerted. Civil defence, police, fire and ambulance. This is done by the site dispatcher.

The local authorities have not been involved in exercising the new site emergency plan.

The status of local authority arrangements is not known

OUTLINE SAFETY DOCUMENT MANAGEMENT SYSTEM		D
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		3
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Information relating to administrative control systems

Provide a summary (based on form D2) of the administrative control systems used to achieve engineering control, operational control and control of materials and their inadequacies:

There are many control arrangements in place covering engineering, operational and material safety management:

Maintenance schedules
Safe working procedures (fire, confined spaces, hazardous areas)
Safety control of modifications
Incident reporting and investigation
Operating instructions for safety sensitive tasks
Maintenance instructions for safety sensitive tasks
Safety directory
Emergency Plan (1993 recently written)
Inventory of hazardous materials
Hazardous material accountancy
Training, authorization and re-examination procedures
Computerised training records
Contractor training and control
Safety inspections by both Management and Safety Department
Hazardous chemical transport procedures - western system being adopted.

There are a number of inadequacies identified:

1 *The Emergency Plan has not been actively put into use as yet. No training or exercising has been undertaken since 1986/1987. The emergency facilities, control rooms, communication, etc are inadequate to cope with an emergency. Consideration needs to be given to the site emergency alert system to differentiate between different types of emergency which may require different responses.*

2 *Operating instructions are 'general' in nature. These require to be re-written in a more specific form - particularly for hazardous operations.*

3 *Maintenance instructions need to be more widely used; they are currently limited in number.*

4 *The Safety Directory requires a review, and needs to be put into a more adaptable ring binder form to ease revision.*

5 *There are no BVM written requirements for environmental control. Since the company has received a number of fines for breaches of environmental limits, this area of control should be improved and documented.*

6 *A more formal approach to the design process is required with the inclusion of Risk Assessment and Quality Assurance.*

7 *The intent to adopt the Western style system of transport safety for hazardous substances should be progressed and implemented fully, and staff should be trained in its application.*

8 *The current action to implement quality assurance to ISO 9000 should be applied to the plant safety management system.*

OUTLINE SAFETY DOCUMENT		D
MANAGEMENT SYSTEM		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		5
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Information relating to training

Provide a summary (based on form D3) of the arrangements (and their inadequacies) which are in place to ensure all staff receive appropriate training for the safety aspects of their jobs:

All staff are trained and authorised to carry out their duties from Directors downwards.

Written tests are given and pass rates of 75% for workers - and 95% for managers - are required.

Retraining and assessment takes place every 4 years.

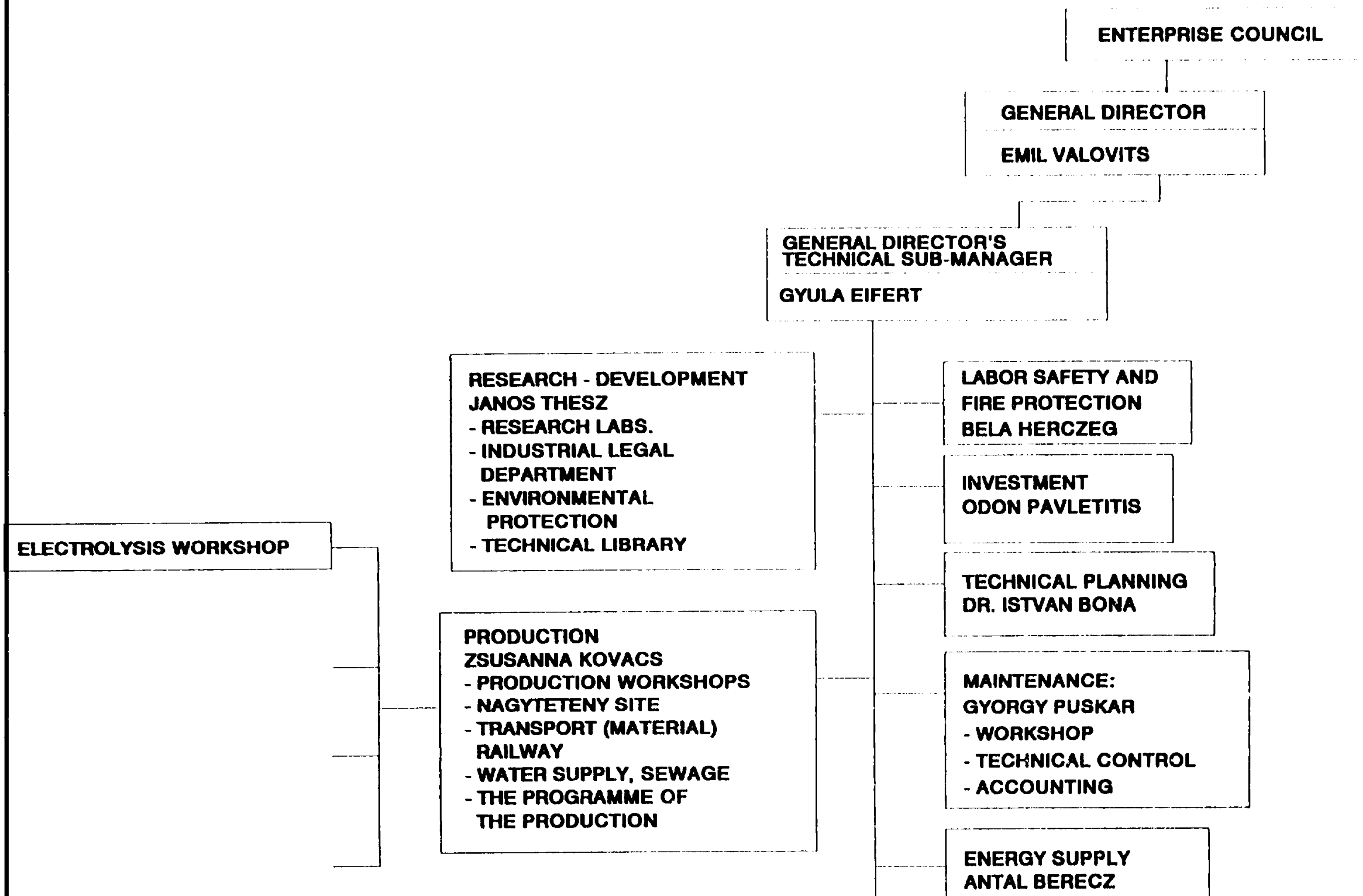
The system is well documented, and training resources are provided, and there is a training school on site.

The system appears to be comprehensive. However, in looking at causes of incidents a major common factor is operator error.

It would be worthwhile to review the adequacy of training bearing in mind the incidents caused by operator error. On job training may need to be improved.

We have suggested improving operating instructions.

BVM TECHINCAL ORGANISATION



ELECTROLYSIS WORKSHOP

WORKSHOP LEADER

GYULA MOLNAR

TECHNOLOGY LEADERS

ISTVAN SZABO

FERENC PUHR

ANDRAS VARGA

SHIFT LEADERS

5 SHIFTS

OPERATIONS STAFF

OUTLINE SAFETY DOCUMENT		D1
STAFF INFORMATION HEADER		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		H
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

List of D1 Forms Attached

No	Job Title	Comment
1	*Technology Leader (A)*	
2	*Shift Leaders*	
3	*Workshop Lerder*	
4	*Technology Leader (B)*	
5	*Technology Leader (C)*	

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: B Blackburn	Signature: [signature]	Date: 1/3/93.

OUTLINE SAFETY DOCUMENT	D1
STAFF INFORMATION	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	1
NUMBER: 1 · ISSUE: 1 · DATE: 16/2/93	
JOB TITLE: TECHNOLOGY LEADER (A)	

Name of current job-holder: *MR FERENC PUHR*

Reports to (job title): *MR MOLNAR*

Deputising arrangements:

Any of the other two Technology Leaders.

Safety responsibilities:

Cell Halls responsibility for operation.
Preparation of salt solution.
Caustic soda filtering department (mercury cleaning).

Safety related decision making:

Responsible for safe operation of the above plant areas.

Qualifications and training:

Qualified Chemical Engineer.

Experience:

Technology Leader in pharmaceutical factory 10-15 years.
Appointed 1991.

OUTLINE SAFETY DOCUMENT			D1
STAFF INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 2	ISSUE: 1	DATE: 16/2/93	
JOB TITLE: SHIFT LEADERS			

Name of current job-holder: *FIVE SHIFT LEADERS APPOINTED*

Reports to (job title): *TECHNOLOGY LEADERS*

Deputising arrangements:

Any of the other Shift Leaders.

Safety responsibilities:

Safe Plant operation on a shift basis.
Authorization of safe working procedures on the plant on a shift basis.

Safety related decision making:

On a shift basis he makes decisions on plant safe operations.
Authority to shutdown plant if unsafe.

Qualifications and training:

Must be a qualified "skilled worker" having attended training after secondary school.
Minimum of 5 years' experience in the chemical plant.

Experience:

See above

OUTLINE SAFETY DOCUMENT			D1
STAFF INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 3	ISSUE: 1	DATE: 16/2/93	
JOB TITLE: WORKSHOP LEADER			

Name of current job-holder: *MR GYULA MOLNAR*

Reports to (job title): *HEAD OF PRODUCTION ELECTROLYSIS WORKSHOP*

Deputising arrangements:

Technology Leaders will deputise in Mr Molnar's absence from site. Technology leaders are trained and authorised to fulfil the deputy role.

Safety responsibilities:

Overall responsibility for safety of operations of the Electrolysis Workshop.

Safety related decision making:

Decides safe operational actions.
Authority to initiate plant shutdown in unsafe situations.
Production of safety operating procedures.

Qualifications and training:

Qualified Chemical Engineer - Hungarian Technical University Trained and authorised by BVM under their competence requirements.

Experience:

5 years' experience at BVM prior to appointment. Appointed in 1990.

OUTLINE SAFETY DOCUMENT STAFF INFORMATION		D1
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		1
NUMBER: 4	ISSUE: 1	DATE: 16/2/93
JOB TITLE: TECHNOLOGY LEADER (B)		

Name of current job-holder: *MR ISTVAN SZABO*

Reports to (job title): *MR MOLNAR*

Deputising arrangements:

Any of the other two Technology Leaders.

Safety responsibilities:

Chlorine Drying Workshop)
Chlorine Liquidisation Workshop) *Responsible for*
Sodium Hypochlorite Workshop) *Safety of Operations*
Hydrochloric Acid Workshop) *in these areas.*
Chlorine filling activities)

Safety related decision making:

Decides on safe operational actions in the above Workshops.
Production of safety operating procedures.
Authority to shutdown plant if unsafe.

Qualifications and training:

Qualified Chemical Engineer.

Experience:

Technology leader for 20 years in BVM.
Appointed in 1990 to this post.

OUTLINE SAFETY DOCUMENT STAFF INFORMATION		D1
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		1
NUMBER: 5	ISSUE: 1	DATE: 16/2/93
JOB TITLE: TECHNOLOGY LEADER (C)		

Name of current job-holder: *MR ANDRAS VARGA*

Reports to (job title): *MR MOLNAR*

Deputising arrangements:

Any of the other two Technology Leaders.

Safety responsibilities:

Sodium Hydroxide Distribution Control and Transport.
Hydrochloric Acid Distribution Control and Transport.
Sodium Hypochlorite Distribution Control and Transport.
Hydrogen Peroxide Distribution Control and Transport.

Safety related decision making:

Decision on safe distribution of the above chemicals - packaging and transport.

Qualifications and training:

High School Chemical Qualification.
Control of Chemical Processes.
Trained and authorised by BVM under their competence requirements.

Experience:

Work in Maintenance Department of BVM.
Appointed in 1992.

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Attachment List

No	Title	ID	Issue	No Pages	Comment
	None				

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: B Blackburn	Signature: [signature]	Date: 1/3/93.

OUTLINE SAFETY DOCUMENT			D2
CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Engineering Control

Control of Design

Is the design process set up to:

a Ensure that the technical objectives are achieved?
b Identify stages of the process where checks are required?
c Provide a specification for safety requirements?
d Identify and accommodate commissioning and maintenance requirements?

No written procedures - relies on experience and communication of staff.
A procedure is required to control the design process.

Is use made during design, commissioning, maintenance and modification of hazard identification and assessment techniques such as:

a Hazard and operability studies (HAZOP)?
b Hazard analysis (HAZAN)?
c Failure Mode and Effects Analysis (FMEA)?
d Fault trees and event trees?
e Reliability assessments?
f Task analysis and installation procedures?

No requirement for formal risk assessment - assessment based on experience.
The used of formal assessment needs to be written into the procedures.

What standards, codes etc are used in the design process?

a Hungarian, other European, US or international standards?
b Company engineering and design standards?
c Company codes of practice?
d Competent authority (regulator) guidance notes?

Use Hungarian standards in design.
No established company codes and standards.
Regulatory and standards office combined - no specific guidance established by the regulatory bodies.

OUTLINE SAFETY DOCUMENT	D2
CONTROL SYSTEMS AUDIT	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	3

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Do company directives and guidance define suitable construction or modification requirements, including:

- a Preparation of work schedules and method statements?
- b Testing and inspection during installation?
- c Approval of test results?
- d Safety assessment of modifications during construction?
- e Handover procedure prior to commissioning?
- f Monitoring, recording and reporting requirements?
- g Material certificates and treatment records?
- h Quality assurance requirements?

Personnel safety document defines handover procedure for safe working and declaration made in form of handover that repairs are carried out to Hungarian standards.

Modifications considered to have safety significance are assessed by jury prior to construction, and prior to operation, and a documented handover prepared.
A re-appraisal of the procedure to improve assignment of modification category would be appropriate.
Currently the workshop leader decides.
Safety directory contains requirements for new equipment.

Control of Maintenance, Inspection and Testing

Are routine maintenance requirements formally identified and schedules produced for each plant item?

2 week outage/year
Some routine maintenance is carried out during operations on equipment that can be released.
New items replace irreparable plant.
Maintenance schedules exist mechanical statutory items are checked to statutory requirements, but a large degree of maintenance (mechanical) is breakdown maintenance. (Finance is a problem - spares costs.)
The maintenance schedule is prepared and administered by the workshop leader. The system is paper based and cumbersome.
A change to computer systems and the development of a planning department would release workshop leaders to spend more time on plant operational management.

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CONTROL SYSTEMS AUDIT		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		4
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Is "safety critical" maintenance, inspection and testing identified and are sufficient safeguards employed for:

a Work with potential to damage plant?
b Work on safety related equipment?

Written procedures for work in dangerous areas, permit its work system is in place.

No detailed maintenance procedures to cover all plant.

Safe working instructions do exist.

Are written procedures in place for the safe handover and hand-back of plant between the operator and maintenance staff?

Labour safety department controls safe working and inspects safety precautions applied on the plant.

There is a permit to work procedure which requires operator permission prior to work, and handback after work.

Are records kept of maintenance, inspection and testing carried out and are any problems encountered analyzed to:

a Improve procedures?
b Identify training requirements?
c Initiate incident investigations?
d Identify incomplete maintenance?
e Record variations to the maintenance procedure?

Records kept of statutory inspections - pressure equipment etc, but other equipment not recorded. It is unlikely that analysis can be carried out formally with the systems in place at present. Finance is a problem in plant facilities.

No comprehensive plant records systems.

Are arrangements in place to ensure that the programmed completion of routine maintenance is monitored to identify and correct any maintenance, inspection and testing backlog?

No formal monitoring system in place - overshoot of maintenance periods can occur.

Workshop leader controls the issue of maintenance work from the schedule.

Are statutory maintenance requirements recognised and is compliance ensured?

It was stated that statutory maintenance requirements are complied with and records maintained - pressurised systems quoted as a typical example.

Are Permit-To-Work (PTW) methods/procedures for controlling hazardous work implemented where maintenance and construction work is performed?

This is a requirement of the labour safety directory.

Is there a procedure by which personnel are made aware of their responsibilities under the hazardous work procedure?

Labour safety directory states the requirements.

Staff with safety responsibilities are tested at periods of 4 years - dependent on responsibilities.

Have all the requirements for specialised safe working procedures been assessed?

This has been addressed for particularly dangerous areas. Not identified that this is comprehensively covered in some form of listing of these areas.

Are procedures applied to control the use of safety critical tools and equipment such as:

a Blanks, spades and disabling devices?
b Lifting tackle and cranes?

a Control of spades has given problems - control is by the maintenance leader noting in the diary - tighter control would be appropriate.

b *Only authorised and examined staff can carry out lifting operations and operate cranes.*

Are acceptance criteria included in maintenance and installation procedures?

Statements are required at handover that maintenance has been carried out to Hungarian standards.

No formal acceptance criteria are issued.

Control of Modifications

Are safety assessments carried out to look at the effect of modification on the plant and how such modifications affect the as-built design safety?

a Are modifications categorised?
b What assessment methods are employed for modifications?
c How and by whom are modifications categorised?
d Are checks made to ensure that the assessment requirements are being applied correctly and the modification procedure applied strictly.

a *Plan is written, and a jury is formed - if the jury approves - the modification is implemented - Protocol signed. Only the areas or workshops are classified in Hazard categories.*
b *Discussion and assessment by the jury. Leader of safety dept, Director of Production, Technical Director, Workshop Leader, Electrical Department Leader Machinery Department Leader.*
c *The workshop leader initially decides how the modifications will be assessed - by jury or others. A procedural document for this process exists.*
d *The jury assesses the modification on completion prior to operation.*

Does the safety assessment process include the implementation stage of modifications as well as the operational stage?

Yes - the installation information package is submitted to the jury for assessment.

Is formal authority and approval required in the procedure before commencement of the proposed work?

Protocol is required to be signed by the jury.

Is a procedure used to control the handover of modified plant between those responsible for the modifications and those who control/use the modified plant and does it include authorization and approval of any concessions?

The authorization and control of concessions is at the workshop leaders discretion. Not referred back to jury.

Committee formed to check paperwork and carry out site inspection (Jury members) before approval for operation.

Are drawings, procedures and training programmes updated as part of the modifications procedure?

Update of associated paperwork and training requirements are considered in the modification procedures. Sometimes modification procedure not applied in cases where it should be.

A tighter control of the modification procedure is required.

Is guidance provided for all those involved regarding the use of a modifications procedure?

There is a procedure written on how modifications must be addressed, workshop leaders are aware there is no evidence of formal training in procedure.

Are quality assurance procedures applied to the design process for:

a Setting company design standards?
b Auditing against those standards?
c Identifying and implementing required corrective actions?

Hungarian design standards for equipment are set.
BVM have not declared QA procedures, but we understand this is being addressed.
Work is carried out to regulatory standards.

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CONTROL SYSTEMS AUDIT			
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Does the commissioning (of new plant) procedures provide rigorous control including:

- a Approved and witnessed commissioning schedules?
- b Approval of procedures and operating instructions?
- c Approval requirements at identified stages?
- d Safety approval of modifications during commissioning?
- e Monitoring, recording and reporting requirements?
- f Handover procedure prior to operations?
- g Quality Assurance requirements?

All the above are not fully in place. In the application of Quality Assurance, the above list should be written into the procedural requirements.

Are methods used to register and update drawings etc so that:

- a Drawing originals are retained at one central location?
- b Superseded copies are destroyed?
- c There is a current list of persons issued with drawings?
- d Unique numbers are issued and copies are controlled?

- *a Originals retained in Technical Planning department, other copies in operators department, 4 copies.*
- *b Yes*
- *c Yes*
- *d Yes*

Are design safety reviews and engineering reviews held at appropriate points in the design, construction and installation of a new facility or modification?

- a Are checklists used to prevent missing out important safety considerations?
- b Is a range of disciplines involved in the review?

Yes. The regular inspections by managers cover modification work to systems.

Design safety and engineering reviews are not a formal requirement.

Is the effectiveness of the engineering and design features of the system adequately demonstrated against company safety standards?

- a Are there relevant design policy statements?
- b Are details of all significant changes recorded?
- c Is auditing and feedback incorporated into the system?

There is a requirement that design complies with Hungarian standards.

Inspection of the process does take place, but not formal QA auditing.

Changes are recorded, but there are no design policy statements for BVM.

Control of Operations

Are company and departmental guidelines used to identify what procedures are required for normal and abnormal operations, and emergencies?

For normal operations, procedures are in place. These are very general, and moves are in hand to introduce equipment numbering and re-write procedures.

Some abnormal operations procedures written. The shift supervisor must be informed of any abnormal occurrence (shift supervisor covers all shifts). If the abnormal situation requires repairs to be carried out, he will decide to shut down or bypass. Event recorded in log - both maintenance and operators record this, and daily meeting discusses this.

On site emergency plan has been written, offsite emergency plan not yet formalised.

Are the results of hazard analyses, new legislation, incident investigations and monitoring used as an input to identify and modify operating or other procedures?

Where incidents indicate the requirement for modification to plant or operating procedures, an action list is produced and target dates set - usually very tight, and action checked.

Environmental protection department and Health and Safety departments are responsible for informing departments of new legislation requirements - government grants are provided for this.

No formal hazard analysis, done by experience and practice.

Monitoring by senior staff and worker protection department may require actions to be taken to modify procedures.

Are there formal safety assessed procedures for all normal plant and equipment operations? Are documentation systems controlled:

a Are suitably qualified and experienced persons selected to develop and improve procedures?

b Are all procedures and instructions subject to a formal check and review process?

c Are all documents periodically reviewed?

d Are all operational procedures registered and subject to controlled issue?

e Are all copies of superseded procedures withdrawn and destroyed?

a Technical director is ultimately responsible. There is a design section but overloaded. Operational plant management write the procedures.

b Procedures checked by various technical support departments, Health and Safety, chemistry etc as appropriate - worker protection (Department) are responsible.

c Yes - checked every year since last year.

d Not previously carried out, but is being introduced.

e As answer d.

Do the company directives and guidance for operational facilities clearly identify the safety requirements, including:

a Formal emergency procedures and exercises?

b Safety approved operational procedures and rules?

c Approved and acknowledged operating instructions?

d Formal maintenance schedules and procedures?

e Safe systems of work which are to be used?

f Monitoring, recording and reporting requirements?

g Procedures for accounting/control of hazardous substances?

h Waste monitoring and discharge requirements?

There are procedural requirements for all the above. The adequacy of these procedures was not checked in detail, but in the annual reviews, plant management consider this.

Are systems in place for the reporting and investigation of any abnormalities, malfunctions, etc?

There is a requirement to report unusual occurrences and 'near misses' - these are investigated as per incidents.

Plant occurrences are recorded in a diary - descriptions of the occurrences etc by the operator. Workshop leader also records this in his log. The cause of occurrences is investigated by the shift team.

Are the procedures for the shut down of plant or process in the event of an emergency adequately promulgated and displayed?

Procedures are written for key shutdown operations and operators are trained to perform them.

Control of Emergencies

Are staff aware of written company guidance on what emergency arrangements are required, and the procedures for implementing them?

There are some emergency operating instructions.

An emergency plan is written, but staff have not yet been trained and no exercises have been carried out since 1986/7.

Arrangements for segregation of alarms to define the type of emergency are required, eg fire, gas release, etc.

Action is required to write, instruct, implement and practice these arrangements.

Do local arrangements exist for communications with external authorities, the media, and the public, in the event of a major emergency, and do they include control of statements, etc?

There are arrangements for communications. However these are inadequate. Consideration needs to be given to control centre equipment and staff duties. If a major release occurred now, the system could not cope.

Local authorities etc - need to develop their detailed plan, and practice this in co-operation with the plant.

Are management promptly informed of all significant incidents or emergencies, as part of a formal information procedure?

There is a contact list in the emergency plan and management are to be informed in the event of a major incident or emergency. They are required to attend and take control.

Do emergency procedures address all accident scenarios required by legislation and those identified in the hazard assessments?

There are no formal hazard assessments.

The instructions and alarms to site personnel do not differentiate between the types of emergency. This needs to be tackled.

An assessment of possible accident scenarios needs to be carried out.

Are emergency procedures practised and assessed by holding:
a Routine emergency drills?
b Periodic large scale emergency exercises?

No - no exercise has been carried out since 1986/7.

Do practices involve all employees and contractor's staff present during the time of the emergency exercise/drill?

No.

Are large scale exercises programmed, which involve emergency and rescue services and all employees and contractors' staff present, to provide a realistic test of the envisaged procedure?

No - this needs to be developed.

Are the results of exercises recorded, analyzed and utilised?

> *No exercises, but this should be done in future in the form of a review meeting of key emergency staff and observers. Inadequacies noted during the exercises should be identified and arrangements improved accordingly.*

Is specific emergency training provided for:

- a Permanent staff?
- b Contractors?
- c Emergency services?
- d Visitors?

> *No - This needs to be properly addressed.*

Are the emergency procedures reviewed at a suitable frequency?

> *A recent emergency plan has been written, but not yet put into action.*

> *Quality assurance introduction should require regular reviews in future.*

Is the provision of emergency equipment such as emergency lighting, fire-fighting equipment, breathing apparatus and emergency egress equipment reviewed to ensure adequacy:

- a Periodically on a regular basis?
- b In the event of modifications to plant?
- c With regard to technological advance?
- d Against changes of legislation?
- e As a result of incident investigations or analysis?

> *Emergency equipment is regularly inspected, however there is no written requirement to carry out formal reviews at intervals of the adequacy of the equipment with regard to legislation or technological advance.*

Are emergency response teams provided and are they suitably trained to perform their required duties of:

- a Fire fighting?
- b Rescue of personnel?
- c Administering of first aid?

d The wearing of respiratory protective equipment?

There are some emergency staff appointed, but practical exercising is not as yet established.

A suitable training programme should be established.

Are installed emergency protection devices tested regularly and the results recorded :

Maintenance schedules require maintenance on safety equipment. The adequacy of these was not checked in detail.

Control of Material

Are Plant/Department arrangements in place for the maintenance of an inventory of all substances which are classified as hazardous or which may become so during a work activity?

Obligatory to make directory (1982) - this is done

National legislation Toxic Order. Handling and transport.

Toxic materials require regulatory permission for storage, usage, and transport - classified according to toxicity.

The arrangements look adequate in this area.

Are there requirements for all such substances to be assessed, suitably labelled and catalogued in order to provide procedures and instructions for:

a Safe storage?
b Safe handling?
c Safe use?

Yes - forced by regulations and applied in the plant.

Protection against spillage/neutralisation/equipment. PPE, fire precautions are in place.

Hydrogen fluoride has on plant instructions, but not all materials have on plant instructions.

Has the following questioning approach and order been applied to the use of hazardous materials used on site?

- a Is the material really needed (can the material be eliminated)?
- b Can a less harmful material substitute for it?
- c What engineering controls can be put in place to reduce the danger (for example deluge/sprinkler systems)?
- d And only as a last resort - what personal protective equipment should be used?

Not in a formal hazard assessment process, but in the process of design and operations by experience of staff.

A formal process could be an improvement.

Are there arrangements which ensure that any work which involves the use of hazardous substances is subject to the requirements of the relevant legislation?

Yes - but money shortage and plant design lead to excessive discharges.

Are quality and safety checks performed on all material which is:

- a Purchased from an external source?
- b Manufactured or produced by operations?
- c Likely to deteriorate over a period of time?

Yes.

Are monitoring arrangements in place which track all materials used and record details of their final disposal route?

Yes - accountancy carried out monthly; some material has been unaccounted for at times.

No continuous monitoring of discharges - done by sampling on a daily basis.

Emission monitoring around perimeters by local authorities.

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CONTROL SYSTEMS AUDIT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			16
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Are arrangements in place which ensure that surplus material is returned to a store and disposed of externally if no longer required?

Storage area is provided and is used for the storage of all feedstock - surplus material is returned to this store.

Have suitably authorised persons been identified, trained and appointed in writing for the receipt, issue and control of particularly hazardous material?

Leader of storage area responsible for his area.

Workshop leaders authorise the control and receipt of dangerous materials for use in his area.

Is training provided and formal assessment required to ensure that material handling plant and equipment is operated only by qualified staff who have been formally appointed?

Yes - operators are trained and authorised, and are tested at 4 year intervals.

Are suitable material handling procedures provided to those concerned in order to ensure that loading, unloading, handling and the storage of material for movements within and outside the Company are carried out correctly to avoid injury and loss?

Procedures are provided in the Safety Directory.

Operators are trained and authorised for the operations on which they are employed.

Specific material handling procedures are written into operating procedures.

European transport safety systems are to be implemented.

Are procedures in place which ensure that any company material which is transported on a public highway has been correctly packaged and labelled according to the relevant legislation?

Western European requirements have to be implemented shortly.

Is there a procedure on waste material which encourages recycling or careful disposal with regard to the environment?

An environmental department monitors waste disposal. However due to plant design, discharge limits are often exceeded. There is no on line monitoring of discharges only random sampling daily.

Has consideration been given to the safety of other storage areas/places of significant hazardous substances belonging to this plant such as:-

a Separate warehousing?
b Transit depots?
c Tank farms?

Yes - storage areas are allocated on site for all hazardous substances.

Are members of the public prevented from entering the premises?

The security arrangements are weak - it is possible for a member of the public to enter the site undetected.

Are the security arrangements appropriate to the hazards of the activities?

No.

Are site boundary fences regularly patrolled, inspected and kept in good condition?

There is no routine procedure for this.

OUTLINE SAFETY DOCUMENT			D3
TRAINING AUDIT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Attachment List

No	Title	ID	Issue	No Pages	Comment
	None				

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: B Blackburn	Signature:	Date: 1/3/93

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OUTLINE SAFETY DOCUMENT		D3
TRAINING AUDIT		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		2
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Do managers receive adequate safety training or have access to suitably qualified and experienced safety advisors?

There is a Worker Protection Department, which provides support in safety issues.

Managers are trained and authorised in the safe operation of their areas. Review of authorization is carried out 4 yearly. Written and oral testing is given with a 90% pass rate. Directors are also externally examined with re-examination 5 yearly.

Do managers identify new training requirements:
- a As a result of incident/accident analyses?
- b As a result of audit, survey, and inspection reports?
- c As a result of new or modified processes or equipment?
- d As a result of changes in legislation?

New training requirements are identified by managers and the Worker Protection Department as a result of all the above issues.

Are suitable teaching facilities and tutors provided in order to meet all the training requirements?

There appear to be no problems regarding the resources for training.

Tutors are provided with training also.

There is a training school on the site.

What training methods are used:
- a On the job training?
- b Internally organised courses?
- c Formal external training?

All three - written and oral examination and formal authorization is used.

Are the requirements for induction and refresher training, identified and programmed?

Yes. This is probably better organised than many Western companies.

OUTLINE SAFETY DOCUMENT		D3
TRAINING AUDIT		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		3
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Are checks made on the training needs of all contractors to ensure that they are met before deployment on the plant?

Contractors statements of competence are required prior to signature of contract.

A BVM Inspector is appointed as contractor liaison. He checks contractor qualifications and liaises with workshop leaders regarding control of contract work.

Induction training is provided for any area in which the contractor is required to work.

Do systems exist for assessment of the effectiveness of training?

Yes - written and oral examinations are given.

Are the training records comprehensive and regularly updated?

Computer records system is in use as a records system and reminder of training requests and refresher training. The labour department feeds labour fluctuations - new recruits, etc into this system.

The record is well maintained.

Are the training requirements for contractor's employees implemented regarding:

a Emergency training?
b Safety training?
c Induction training?

Yes.

OUTLINE SAFETY DOCUMENT			E
ASSESSMENT METHODS			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Attachment List

No	Title	ID	Issue	No Pages	Comment
	None				

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

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OUTLINE SAFETY DOCUMENT		E
ASSESSMENT METHODS		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		2
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Methods list

Method	Stage	Nature	Purpose	Additional Information and References
HAZOP	*HID*	*Group brainstorm session*	*Hazard ID*	*See guidance notes*
Plant inspections	*HID*	-	*Identify additional hazards and pipework characteristics for risk assessment*	-
CIA Chlorine Releases	*CON*	*Nomographs*	*Release rates*	*See guidance notes*
DENZ	*CON*	*Computer programme*	*Model instantaneous releases of chlorine*	*See guidance notes*
CRUNCH	*CON*	*Computer programme*	*Model continuous releases of chlorine*	*See guidance notes*
Risk calculations	*RSK*	*Computer spreadsheets*	*Calculates individual and societal risks*	*See Section F, Attachment 1*

OUTLINE SAFETY DOCUMENT		E
ASSESSMENT METHODS		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		3
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Overview of Hazard Assessment

Hazards were identified by two means:

- a 1½ day high level HAZOP session was carried out involving plant personnel. This was structured around the P&IDs prepared for the study (C2, Attachment 3) and some generic keywords.

- a 1 day plant inspection carried out by an HSE Principal Specialist Inspector.

The outcome of these two activities was then incorporated into a list of hazards. The assessment of severity and likelihood was then made against a categorised scheme and plotted out on a risk matrix (harm to man only). The potential accidents to be studied further were identified. These consisted only of chlorine releases with the potential for offsite effects.

Frequency and consequence were then estimated in more detail. For frequency the method used was the generic frequency approach put forward in the guidance; for consequences, the release rates were estimated using the Chemical Industries Association "General Guidance on Emergency Planning within the CIMAH Regulation for Chlorine Installations". The releases were then sorted into a very limited set and off-site consequences calculated using the SRD codes DENZ and CRUNCH as appropriate.

Finally, the results are combined in a risk calculation performed with a spreadsheet to determine individual and societal risk.

Classification scheme: likelihood

Class	Description	Approximate frequency	Approximate recurrence time	Descriptive recurrence time
A	*Often happens*	*10 per year*	-	*Many times per year*
B	*Has happened*	*0.3 per year*	*3 years*	*Every few years*
C	*Might happen*	10^{-2} *per year*	*100 years*	*Many times in thousand years*
D	*Unlikely to happen*	3×10^{-4} *per year*	*2,000 years*	*Every few thousand years*
E	*Extremely unlikely*	10^{-5} *per year*	*100,000 years*	*Many times in a million years*
F	*"Incredible"*	3×10^{-7} *per year*	*3,000,000 years*	*Every few million years*

Categorisation scheme: harm to man

Class	Description
A	*No effect*
B	*Worker injury*
C	*Worker death*
D	*Multiple worker deaths*
E	*Off-site deaths*

OUTLINE SAFETY DOCUMENT			E
ASSESSMENT METHODS			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			5
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Categorisation scheme: harm to the environment

Class	Description
A	*No effect*
B	*Environmental nuisance*
C	*Minor environmental incident*
D	*Major environmental incident*
E	*Environmental catastrophe*

OUTLINE SAFETY DOCUMENT	E1
SUBSTANCE INFORMATION	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	1

NUMBER: 1	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: Chlorine		

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Tables (Table 1 - Toxic effects of chlorine; Table 2 - Medical effects of chlorine; Table 3 - Physical properties of chlorine)*			*1*	

Revision History

Date	Issue	Comments
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OUTLINE SAFETY DOCUMENT			E1
SUBSTANCE INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			

Identity, Composition and Handling of the Substance

Substance identity: *CHLORINE.* *Chemical name*
Cl_2 *Empirical formula*
7782-50-3 *C.A.S No*

Degree of purity of the substance: *98 - 99.5% Cl_2*

Main impurities

Impurity	Relative percentage
Water, H_2O	*<0.5%*
Hydrogen, H_2	*<2%*
Nitrogen Trichloride	*Not known*

Detection and determination methods available to the installation:

Water:

Dew point measurements taken in gas stream to measure effectiveness of dryers.

Hydrogen:

Gas volume contraction measured after reaction with Cl_2 to form HCl when exposed to UV light.

Methods and precautions laid down in connection with handling storage and fire:

Venting of chlorine trapped in pipework either to the sodium hypochlorite plant or via the compressor to return to the bulk tanks. In the event that the hypo plant does not cope with all the chlorine, this would be discharged to atmosphere via a large stack.

OUTLINE SAFETY DOCUMENT SUBSTANCE INFORMATION		E1
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		3
NUMBER: 1	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: Chlorine		

Emergency measures laid down in the event of accidental dispersion:

All operators issued with personal escape canister respirators for escape.

For other emergency measures see the on-site and off-site emergency plans.

Methods available to render the substance harmless:

Absorption at sodium hypochlorite plant in sodium hydroxide.

Brief Indication of Hazards

Immediate hazards for man:

Chlorine is a highly toxic gas. At high concentrations it is instantly fatal. An indication of the range of effects is given in the attached Table 1. The principal medical effects are outlined in Table 2. HSE use a toxic load of 108,000 ppm^2 min as being sufficient to be fatal to a small proportion of the population. These would be the most vulnerable, the sick, elderly and the very young. The concentration which would be lethal for 50% of a typical affected population would be around 5 times higher.

Delayed hazards for man:

The technical literature indicates that people would be expected to recover from a single exposure of chlorine if it was not severe enough to cause permanent damage. However there would be severe demands on hospital and other medical services.

Immediate hazards for the environment:

Localised scorching of vegetation and toxic damage to animals and fauna generally. Water courses would be affected by dissolution of chlorine, its presence could be detected by smell.

Delayed hazards for the environment:

Not known.

OUTLINE SAFETY DOCUMENT			E1
SUBSTANCE INFORMATION			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			4
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			

Behaviour of the Substance

Chemical and/or physical behaviour under normal conditions of use:

Under ambient temperature and pressure chlorine is a pungent green gas. On cooling and compression it is liquified. Storage and transfer conditions at BVM mean that it is a liquid held above its boiling point and therefore it is under pressure. Some physical properties are given in attached Table 3.

Forms in which the substances may occur or into which they may be transformed in case of foreseeable abnormal conditions:

Liquid chlorine would be expected to vaporise on release, drawing its heat from the ground and the surrounding air. If the spillage is sufficiently large a boiling pool may form. There may be sufficient moisture to form chlorine hydrate or for the pool to cool below its boiling point - reducing the evaporation rate. At higher temperatures chlorine reacts vigorously with steel, including steel pipework and therefore the risk of fire needs to be controlled and minimised.

E1: ATTACHMENT 1

Concentration (ppm)	Effect
1000	May be fatal even when exposure is brief (a few breaths).
400-300	A predicted average lethal concentration for 50% of active healthy people for 30 minute exposure.
150-100	More vulnerable people might suffer fatality from 5-10 minute exposure.
20-10	Is dangerous for half to one hour exposure. Effects are immediate irritation of nose, throat and yes with cough and lachrymation.
10	Exposure for less than 1 minute causes coughing.
3-6	Causes stinging or burning sensation but tolerated without undue ill effect for up to 1 hour.

Table 1: Toxic Effects of Chlorine

The principal effects arising from a single exposure of animals or humans to chlorine gas are exerted on the mucous membranes: sensory irritation of the eyes, nose and upper respiratory tract, and inflammation and necrosis of the respiratory tract epithelium, lung oedema and congestion. There are also some reports of skin irritation and burns. Mortality results from lung damage and deaths occur rapidly (within hours to a couple of days post-exposure) due to oedema and congestion or can be somewhat more delayed (several days) due to secondary pneumonia. There is no convincing evidence of serious long-term sequelae following a single exposure to chlorine.

Table 2: Medical Effects

Property	Value
Molecular weight	70.906
Boiling point at 1.0133×10^5 Pa	238.4^0K
Freezing point at 1.0133×10^5 Pa	172^0K
Vapour pressure at 273^0K	2.65×10^5 Pa
Density at 273^0K 1.033×10^5 Pa	3.214
Water solubility at 273^0K 1.0133×10^5 Pa	14.6 kg/m^3
Conversion factor at 298^0K 1.0133×10^5 Pa	1 ppm = 2.90 mg/m^3

Table 3: Physical Properties of Chlorine

OUTLINE SAFETY DOCUMENT	E2
HAZARD IDENTIFICATION	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	1

NUMBER: 1	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: All (see Section B)		

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*S Porter Inspection*			*5*	
2	*HAZOP Records*		*19/1/93*	*12*	*HAZOP-PC printout*
3	*Hazard Overview*			*3*	*Rep!aces standard table*
4	*Risk matrix of harm to man*			*1*	*First estimate*

Revision History

Date	Issue	Comments
16/2/93	1	First issue prepared by SRD

Prepared by: A Garlick	Signature: [signature]	Date: 23/2/93

DRAFT C

OUTLINE SAFETY DOCUMENT	E2
HAZARD IDENTIFICATION	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	2

NUMBER: 1	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: All (see Section B)		

Supply the requested information in a suitable format *See attachments*

Hazard	Cause	Safeguards	Consequences	Potentia! Major Accident?	Reasons

E2: ATTACHMENT 1

Report on the Inspection of BVM, Budapest, January 1993

S.R. Porter, Principal Specialist Inspector, Major Hazards Assessment Unit, Health and Safety Executive

The following paragraphs are notes on the inspection of the Chlorine handling activities which I saw at our recent visit. The comments are not intended as an exhaustive list of requirements which would enable the company to comply with British safety law, since the Hungarian system does not appear to allow the operation of the ALARP principle and I am not clear about the role of the regulatory authorities. In Britain the regime of regular inspection and powers of enforcement has resulted in continual improvements in safety whereas the Hungarian plant may not have experienced this progressive influence.

On Site Hazards to the Workforce and Visitors.

1. BVM generate Chlorine by the electrolysis of Brine in cells where Mercury is the Cathode material. The Chlorine is compressed and cooled to liquefy it, stored in insulated storage vessels, dispatched in railcars, drums and cylinders and used in the manufacture of hydrochloric acid and sodium hypochlorite. During the visit I identified the following safety problems to employees and visitors:

Exposure to Chlorine
Exposure to Mercury
Exposure to high magnetic fields
Fire and Explosion hazard associated with Hydrogen generated when the Mercury/Sodium amalgam is washed with water.
Risk of falling from railcar loading platform
Risk of Electrocution at Rectifiers for Cell Rooms
Machinery Guarding Problems in the Compressor Room
Exposure to Ultra-Violet Light

2. Exposure to Chlorine.

Although the pipework in the cellrooms is normally at a slightly negative pressure and any small leaks would be expected to be inwards, there was a slight odour of Chlorine especially in the old cell room. The ventilator in this room was not in use because we were told that at low current loading its operation was not necessary to sweep Chlorine from the cells. When the ventilator is working there may be some localised higher pressure Chlorine sources which could leak outwards. This may be a design problem in the process that the compressors drawing the gas stream through the washing and drying parts of the process are not sufficiently effective. In addition, the isolation for each cell was provided only by a piece of bent hose, wired double to effect closure; this may have been allowing air to enter the system reducing the efficiency of the compressor and ventilator.

3. All operators and visitors are issued with cannister respirators with which to effect an escape from a Chlorine release if one were to occur. This type of respirator is less effective if the wearer has any facial hair. Some companies in Britain who issue this equipment forbid the growing of beards and moustaches and visitors are not permitted on to the site if they have facial hair.

No instructions were issued as to what to do in the event of a release. The wind direction indicator was not pointed out and we were not told to escape across the wind direction or upwind of the release. The wind direction indicator was not visible from the Chlorine plant; a local wind sock would be useful here.

4. I did not see any longer term breathing apparatus which might be used in order to turn off the source of any release. However this is one point that I did not specifically look for. Self contained Compressed air breathing apparatus with a duration of 30 minutes would be suitable for this purpose. This should be to hand at the Railcar and drum filling operations at locations either side of the operations so that even if one of the locations is enveloped in the gas cloud the other one should be available.

5. Exposure to Mercury.

Mercury is a liquid at ambient temperatures and pressures. However, experience has shown that the high vapour pressure and the difficulty in cleaning the spilt liquid can lead to extremely high exposures which are difficult to monitor because of the absence of any odour. I would recommend the following measures which would assist in reducing the personal exposure of the workforce to Mercury:

a) Considerable amounts of Mercury have probably been spilt and have entered the pores in the concrete floor. Any amount of cleaning would probably not remove this. It would probably be more effective if a suitable floor sealant were to be found so that future spillages were not to enter the concrete and could be effectively cleaned. Visible liquid Mercury should be removed under suction to a reservoir with a small amount of water in it to prevent the pump expelling Mercury vapour into the atmosphere. Residual Mercury can be removed by washing the floor with a Sulphur and water mixture.

b) The video of the BVM plant indicated that there could be considerable exposure to Mercury in the operation to clear blockages in the amalgam flow. If possible this operation should be carried out under water or in a ventilated cabinet exhausted to a safe place. As a last resort air-line breathing apparatus could be used. It is important that the compressed air feeding the suit should be drawn from a place which guarantees a supply of fresh air.

c) Mercury can also enter the body by ingestion and possibly by skin absorption. It is therefore essential that employees are encouraged to wash thoroughly before eating or smoking periods and before leaving to go home. I would recommend a system of Clean and Dirty areas in the vicinity in which the operators (and visitors) enter through the Clean area, change from their own clothes into ones which they only wear in the operation of the cell rooms. Experience in Britain has shown that it is difficult to keep the Clean Areas clean even on thorough washing and some Mercury factories in Britain use disposable outer clothing to reduce the build-up of Mercury. If Mercury is found on employees shoes, then rubber boots put on when entering and a sulphur/water dip on leaving the cell rooms could be included in the regime. Visitors could be issued with overshoes.

When leaving to go home or for a meal break, employees pass through the dirty area and shower before putting on their own clothes again in the clean area. This also reduces the possibility that employees could be taking Mercury home on their clothes and shoes, re-exposing themselves and also exposing their families to Mercury.

E2: ATTACHMENT 1

6. Exposure to High Magnetic Fields

The high electric currents involved in the electrolysis process mean that there are localised areas of high magnetic fields especially around the conductor bars which pass the current to the cells. This has been known to affect the performance of heart pacemakers. Employees with such devices should not be allowed to work in the cell rooms or in areas where these magnetic fields are to be found (beyond where the current is rectified to DC). Visitors should be asked whether they have such devices and not allowed to proceed to the cell rooms if they have a pacemaker.

7. Fire and Explosion Hazard from Hydrogen

The company are aware of this risk and have constructed a concrete wall around the water sealed gasholder used to store hydrogen from the amalgam washing process. However, as a visitor to the site I would have been expected to have been checked for smoking materials or electrical equipment, for example battery driven cameras, likely to provide a source of ignition for any leak of Hydrogen.

The company had not provided heating in the water seal for the hydrogen gasholder. This might be a problem but I am not familiar with Hungarian winter temperatures. The problem could easily be resolved by installing a steam line into the water reservoir for use in very cold weather.

8. Risk of Falling from Railcar Loading Platform

We examined the valves used for delivering Chlorine into the railcar from a small platform constructed on the top of the railcar itself. In Britain it is a duty to provide a safe working platform, especially when it is necessary to work at heights over 2m from the ground. There should be adequate edge protection to prevent employees falling from the platform. It was my view that the protection provided was not high enough to do this. In Britain a loading gantry would be installed at the rail loading point providing safe access to the loading valves and an interlock to help prevent the railcar pulling away before loading was complete.

9. Risk of Electrocution from Rectifiers Etc

There was open access to the cabinets containing the rectifiers converting power for the cell rooms. In some cases there were keys in the doors and in some no locks on doors at all. Access to such high voltage and current power sources should be under management control and a permit to work system.

10. Machinery Guarding Problems in the Compressor Room

Some of the machinery guards were incomplete or missing in the compressor room. In Britain it is an absolute duty that access to machinery which can cause injury must be prevented.

11. Exposure to Ultra-Violet Light

The routine analytical test for the presence of Hydrogen in Chlorine involved shining an ultra-violet lamp onto a sample of the gas stream contained within a glass burette or pipette. Although the lamp we observed was pointing towards a wall and away from the operator carrying out the test, it was still possible for him to receive UV radiation directly into the eye. This type of exposure should not be allowed and can be suitably controlled by enclosing the lamp in a tunnel into which the sample can be passed, without the operator or anyone else in the vicinity, being able to see the lamp directly.

E2: ATTACHMENT 1

Off-Site Hazards

12. Releases of Chlorine from the site pipework or vessels would be expected to lead to an off-site effect. The following events were considered to be the most likely sources of any release.

a) Failure of pipework carrying Chlorine from the cellrooms to the dryers. This pipework is generally at a low or negative pressure. Small leaks would be expected to be inward and only large failure, for example guillotine failures might lead to an off-site effect. It is therefore important to be able to detect such a failure quickly and to turn off the power supply to the cells to prevent the generation of further Chlorine. In Britain this would normally be achieved automatically with a high pressure sensor in the gas line or other similar device.

b) Failure of pipework carrying Chlorine vapour from the dryers to the compressor building. This pipework is particularly vulnerable because it crosses the road at a low level with no protection against impact. It would be sensible to provide this pipework with a proper pipe bridge or to re-route it across the concrete pipe bridge a little further away.

c) Failure of liquid Chlorine pipework used to fill the bulk storage vessels. The most likely cause of this is either impact at a maintenance operation or by accidentally trapping liquid Chlorine between two closed valves. The latter would lead to a small amount of forward liquid flow and a vapour flow from the headspace of the bulk tank which could only be stopped by the closure of a manual valve at the top of the storage vessel. Breathing apparatus would be required to carry this out and the release might be prolonged.

d) Failure of liquid pipework taking Chlorine to the evaporators and the rail and drum filling plants. A forward flow of Chlorine from the bulk tanks driven by the padding pressure being used in the transfer operation would result from this type of failure. Even if it were possible to switch the compressor off it would take some time for the pressure to reduce and it would only reduce to the saturated vapour pressure of the Chlorine in the vessel. In Britain, Chlorine detectors in the area of the liquid Chlorine pipework automatically close valves to stem liquid Chlorine flow. At the meeting we discussed measures which could reduce the time taken to isolate the bulk tanks in the event of an emergency. This might best be achieved by having a single dip-pipe in each bulk storage vessel, manifolded to the different Chlorine destinations. A single valve could then isolate the liquid outlets from each vessel. In Britain this would be an automatic valve actuated by Chlorine detectors or by an operator pressing a remote emergency button in response to an alarm.

e) Failure of liquid pipework at the filling of railcars. This could be caused by an unsatisfactory connection at the railcar or by a driveaway. The method of filling, into the vapour space of the tanker would preclude a liquid backflow but the liquid forward flow from the bulk tanks should be controlled in a similar way to para 7d) above. In this case strategically placed control buttons could be used to operate the bulk tank control valve.

We discussed the arrangements for filling of railcars and drums. The system did not allow the displacement of vapour to allow filling to take place in one operation. Rather, the operator had to vent several times to admit more Chlorine to the vessel. This procedure is prone to operator error because so many valve operations are involved. It also means that high padding pressures are required in the bulk tanks to carry out the transfer. I would suggest that the system is altered so that the tanker (or drum) is continuously vented during filling.

E2: ATTACHMENT 1

This may require a redesign of the valve arrangement in the railcar. This is discussed further in para 11 below.

f) Failure of the liquid Chlorine pipework at the drum filling operation. The most likely causes of this type of failure are drum roll away or an accident involving the lifting of an adjacent drum. At the meeting we discussed the provision of cradles on the on the drum storage platform and on the weigh scales to reduce the likelihood of a roll away. I understand that the operators are instructed not to carry out a lifting operation whilst another drum was filling but the delivery pipework to the filling point was very close to the scales and could have been damaged during a lifting operation.

g) In Britain, releases from holes in storage vessels and whole vessel failure are considered for the purposes of land use planning. These could typically be caused by impact at a maintenance operation, corrosion or some other undetected defect in the vessel. I include here drums, cylinders and railcars as storage vessels. I was concerned that during the life of some of the storage vessels, test pieces had been taken from some of them and the vessels repaired. This is likely to impair the performance of the vessel and could in itself introduce a defect. It might be better to keep a sample from the original vessel material of construction if such tests are required. Other tests should be of the non-destructive type.

h) The bulk storage vessels were fitted with a bursting disc and safety valve arrangement relieving to the Sodium Hypochlorite plant. In Britain there would be an intermediate expanse tank of at least 10% of the capacity of the bulk tank. This could be used to hold up liquid Chlorine to be released slowly to the Hypochlorite plant in an emergency. It would also be useful if an incident occurred when the Hypochlorite plant were not available for some reason.

I would recommend that the company calculate the capacity of the Sodium Hypochlorite plant to absorb large quantities of Chlorine without exhausting or boiling the sodium hydroxide. If its capacity or availability is in doubt then an intermediate vessel should be installed. The entrance valve to this vessel should be locked open. The exit could be locked closed until required in the event of an emergency.

13. Railcar Design

There are certain differences in the design of the railcar seen at BVM and railcars seen in Britain. To facilitate continuous venting at the filling operation, filling can take place through a dip pipe. To prevent this causing a liquid backflow on failure, an excess flow valve or a valve of the Phoenix type is fitted (compressed air supply keeps this valve open and if the air supply fails, the valve closes automatically). This arrangement is particularly important at the receiving end of the journey, to prevent forward flow in the event of a failure of the liquid offloading line.

14. Road and Railcar Filling Operations

In Britain, Chlorine is transported in bulk by both road and rail. The loading and unloading arrangements for such vessels vary according to the numbers of them which might be filled or unloaded each year. However for a manufacturer where several road and rail vehicles could be filled each day, safety provisions are usually to a higher standard than for a receiving site where there might only be 10-20 deliveries per year. On a manufacturers site I have seen some of the following provisions for safety:

a) The vehicle stands on a weigh scale or load cell to monitor the amount of Chlorine loaded. As the amount reaches the limit for the vehicle, the flow is stopped automatically. This reduces the likelihood of overfilling.

b) Interlocked barriers to prevent Chlorine driveaway during loading.

c) Interlocked pipe testing to prevent the use of pipework unless it has been rigorously pressure and leak tested before commencing loading.

d) Movement detectors connected to automatic shut-off valves to reduce the duration of any spillage in a roll away situation.

e) Chlorine detectors connected to automatic shut-off valves.

f) Some Chlorine loading/unloading operations are carried out indoors. This can have dramatic effect on the off-site effect. It also gives any Chlorine detectors a better chance of detecting any release and might allow small leaks to be effectively removed to a scrubber by forced ventilation.

15. Piping Standards

Where piping is being used to convey a hazardous substance such as Chlorine, the consequences of a failure in such pipework have serious implications both for employees and for the off-site population. It is very important that additional care is taken in the design, construction and maintenance of such pipework. Some examples of poor pipework arrangements were given in para 12 above. Especial attention needs to be given to pipework supports in the compressor room where the pipe taking Chlorine up to the condensers was particularly badly supported, in a busy plant area.

There were indications that although valves had been selected for their resilience on Chlorine duty, the interconnecting pipework was not of a similar standard. I would expect these pipes to be more susceptible to corrosion and erosion failure. If it is not possible to obtain correct pipe materials a more rigorous testing regime needs to be established and a regular replacement program started if found to be necessary.

Session 1 for BVM1

Company: BVM
Location: BUDAPEST
Facility: CHLORINE PRODUCTION AND STORAGE

Session Date: 18 01 93 Drawing No.: C2: Att. 2

	Name	Phone number	Location
Leader:	Andy Garlick		
Secretary:	Russ Ralph		
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Comments:

Company: BVM
Facility: CHLORINE PRODUCTION AND STORAGE

Node: 1
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Session: 1 18 01 93 Revision: 0 18 01 93 Dwg#: C2: Att. 2
Node: 1 ELECTROLYSIS (1,2)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
FIRE HAZARD	Hydrogen leak ignited by electric motors	Hydrogen fire in the cell room	Control of ignition sources. Fire proof electrical equip. and high ventilation rate in the cell room.		
	Fire in downstairs room	Pipeline failure chlorine. Possible structural collapse.	Stop chlorine production.	Check fire safety in cell rooms (plastics and non protected electrical items)	Grading subject to quantities of hazardous materials.
			Structural protection on walls and sub-frame.		
			Permit system for hot work.		
			Fire mitigation systems (extinguishers, water curtains)		
			Fire classification grade C protection (lowest classification).		
	Fire water run off	Posible environmental hazard	Collected by site drainage system and treated on site. Storage capacity is about 100m3.		
EXPLOSION HAZARD	Production of Hydrogen above flammable limit in chlorine cell. Caused by contaminants in brine.	Release of brine and chlorine gas from cell (3-5kgm).	Cleanliness of brine.		Worker hazard.
			Monitoring of chlorine.		
		Missile generation			
		Mercury contamination (50 tns in cells, 30-40kg in each cell).		Check mercury procedures.	
TOXIC RELEASE HAZARD	Evaporated mercury in the air.	Occupational hazard.	Hygiene procedures.		
	Failure of chlorine suction.	Release of chlorine in room (1.5kg/s)	Electrolysis shutdown on loss of power to compressors.	Check how compressor shutdown leads to electrolysis shutdown	
			Shutdown of electrolysis on loss of associated compressor for any reason.		
			Extraction of residual chlorine. (Natural circulation?)		
	Low suction. Operator error.	Less than above	PPE. Plant shutdown.		
	Existing leak plus spurious start-up of auxilliary blowers.		Continuous manning for chlorine monitoring by smell (in procedures).		
VENTILATION HAZARD					Natural ventilation via convection. Air channels exist between first and ground floors.
LOSS OF SERVICES	Loss of power.	See above.			

Company: BVM
Facility: CHLORINE PRODUCTION AND STORAGE

Node: 1
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Session: 1 18 01 93 Revision: 0 15 01 93 Dwg#: C2: Att. 2
Node: 1 ELECTROLYSIS (1,2)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
HAZARD	Loss of cell circulation.	Cell boiling and destruction.	Operator intervention. Current control (trip on high voltage).		
	Loss of ventilators (dwg 1).	Small chlorine release.	Operator intervention and backup supplies		
	Loss of brine recycle pump.	Release in cell room. Will be rapid release of all chlorine in cells.	Operator intervention on high level alarm.	Check why chloine released and not sucked to compression.	
CONTAMINATION HAZARD	See above (explosions). Normally 2% contamination (1% hydrogen, 1% oxygen and air).		Plastic piping as protection against corrosion. Laboratory analysis of chlorine.	Check air content under compression. Also check on water content.	
IMPACT DROPPED LOAD HAZARD	Crane operations	Release of chlorine in cell room.	Instructions for crane operations and licensed operators. System of certification.		
MAINTENANCE HAZARD	Leak of chlorine or hydrogen following maintenance.	As above.	Pressure testing.		
	Ignition of leak of hydrogen by hot work.	As above.			Has happened.
OPERATOR ERROR HAZARD	Monitoring failures.	As above.	Also checked in drying area.		
ENVIRONMENTAL HAZARD	Drainage	Pollution of Danube.	Insufficient quantities.	Check level of water table and posible environmental problems in other areas.	
OTHER HAZARD	Electrical shock.	Occupational risk.	Design.		
START-UP AND SHUT DOWN	Explosion hazards due to start up conditions.	See above.	Routeing to hypo plant.	Check explosion hazard dealt with under hypo plant.	

HAZOP-PC 2.02 Worksheet Primatech Inc.

Company: BVM
Facility: CHLORINE PRODUCTION AND STORAGE

Node: 2
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Session: 1 18 01 93 Revision: 0 18 01 93 Dwg#: C2: Att. 2
Node: 2 WASHING AND DRYING (4,5,6)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
FIRE HAZARD	Fire in drying room.	Chlorine release at production rate.	Plant shutdown.		
EXPLOSION HAZARD	Drying increases explosion risk.	As above.	Bursting disks (or sections of pipe?).		
			Sealed system.		
TOXIC RELEASE HAZARD	Pressure variation.	Potential for small chlorine release.	Constant manning.		
	Chlorine leak through sulphuric acid system.		Sealed cascade.	Check how H2SO4 system works and if a leak is possible.	
LOSS OF SERVICES HAZARD	Loss of water supply leads to corrosion failures	Sulphuric acid release.	Temperature monitoring of cooling water and sulphuric acid.		
	Loss of sulphuric acid supply.		Adequate supply in header tank for several days.		
CONTAMINATION HAZARD	Sulphuric acid droplets in chlorine line.		Sulphuric acid lubrication on compressors and filters thereafter.		
ENVIRONMENTAL HAZARD	Total loss of sulphuric acid (less than 10m3).	Possible environmental hazard.	Hold up basin.	Check procedures for hold up basin.	
OTHER HAZARD	Storage of sulphuric acid tanks. 2 out of 4 not bunded.	As above.			

HAZOP-PC 2.02 Worksheet Primatech Inc.

Company: BVM Node: 3
Facility: CHLORINE PRODUCTION AND STORAGE Page: 1

Session: 1 18 01 93 Revision: 0 19 01 93 Dwg#: C2: Att. 2
Node: 3 COMPRESSING AND FILTERING (7)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
FIRE HAZARD	Hydrogen gas in quantities greater than 5%.	Possible plant destruction.	Mixture is burnt. Fiercer burn signifies higher levels of hydrogen.	Check explosion hazard under condensation.	
TOXIC RELEASE HAZARD	Valve failure.	Small chlorine release.	Use ammonium hydroxide to detect chlorine (forms a fog).		
	Filter shell failure.	Possible lage chlorine release (at production rate)	Annual inspections. Ventilation system.		
	Compressor bearing failure.	Small release.	Temperature monitoring of sulphuric acid which is alarmed.		
	Failure/blockage of sulphuric acid cooling system.	As above.	Sight glass for sulphuric acid.		
	Closure of compressor by-pass by operator.	Possible large chlorine release due to over pressure.	Not a logical action.		
		Air sucked in at cells.	Excess chlorine goes to hypo plant. Depends upon valve opening by operator.		
		Overpressure if hypo valve not open.			
LOSS OF SERVICES HAZARD	Loss of electric power.	Possible chlorine release in cell room.	Back-up power supply. Loss of power to compresser leads to loss of power to electrolysis (automatic system).	Check these systems.	
	Local loss of power.	As above.	Automatic system as above.	Check system.	
	Loss of water to acid coolers.	Acid heat up and potential bearing failure.	Temperature measurement on sulphuric acid system.		
CONTAMINATION HAZARD	Sulphuric acid in chlorine in outlet valves. Failure to close.	Possible chlorine hazard on maintenance.	Separation and filtering systems.		
MAINTENANCE HAZARD	Ignition source.	Oil fire.	System closed down and emptied when work takes place. Permit to work system.	Check source of oil.	
ESCALATION HAZARD	Nearby fire from storage area.	Possible chlorine release.	Plant shutdown.		No specific checks that electrolysis plant has been shutdown before compressor shutdown.

HAZOP-PC 2.02

Worksheet

Primatech Inc.

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Company: BVM
Facility: CHLORINE PRODUCTION AND STORAGE

Session: 1 18 01 93 Revision: 0 19 01 93 Dwg#: C2: Att. 2
Node: 4 CONDENSING (8)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
TOXIC RELEASE HAZARD	Valve failure.	Liquid chlorine release.			
CORROSION	Condenser leaks.	Higher presure freon in chlorine - not dangerous.	Inspections of condenser. Pressure control on freon circuit.		
	Corrosion on water side. Known problem.	Not a hazard.			
EXPLOSION HAZARD	Increase in concentration of hydrogen by condensation.	Plant destruction and chlorine release.	Hourly checking. If high levels checking frequency increases. Transfer to hypo plant increased. Can also be sent to HCl plant.	Check if H can be carried over in liquid chlorine.	Continuous hydrogen monitoring may be required.
LOSS OF SERVICES HAZARD	Loss of water and power.	Decrease in efficiency of condensation.	Excess chlorine sent to hypo plant.		
CONTAMINATION HAZARD	Water in freon.	Operability problem.			
MAINTENANCE HAZARD	Leakage during condenser maintenance.	Major chlorine leak.	Visual checks that valves closed. Major jobs spade off.		

Company: BVM
Facility: CHLORINE PRODUCTION AND STORAGE

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Session: 1 18 01 93 Revision: 0 19 01 93 Dwg#: C2: Att. 2
Node: 5 STORAGE AND LIFTING (10,12)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
TOXIC RELEASE HAZARD	Valve leaks.	Small chlorine releases.	Checked with ammonium hydroxide each shift.		Not done on busy shifts.
	Pipework failures due to liquid chlorine expansion.	Sudden moderate chlorine releases.	Use of accumulators on pipes that can be closed off.	Check operation of accumulators.	
	Small tank leaks.	Chlorine release.	Klingerit (?) seal on flanges etc.		
	Major tank failure	Large sudden chlorine release	Water+ air pressure test and ultrasonic thickness measurements every two years.		
	Flange leaks.	Small chlorine releases.	All the seals are Klingerit, easily differentiated from rubber seals.		
	Instrument fractures.	Moderate chlorine releases.	Depressurise before work.		
FIRE HAZARD	Fire in tank room.	Major release.	Fire protection equipment. Fire proof material.		No alarm.
	Flammable material covering tanks + bitumen based materials for pipework.	Large release.	Control of ignition sources.		No procedures for control of flammable materials.
EXPLOSION HAZARD	Air holder explosion.	Possible missile generation and punctures.	30m seperation and brick walls.		
FILLING HAZARDS	Operator error leads to overfill.	Liquid chlorine sucked back in compressor.	Emergency alarm if certain level reached. 2 operators present during filling.		
VENTILATION HAZARD	Ventilation unavailability during release.	No release extract.	Extracts from the tank room to the hypo plant. Spare ventilator.	Check emergency system availability.	
	Fire in duct due to foreign material.	Failure of extract and fire spread	Extract ducts kept clean.		We have seen material in ducts.
CONTAMINATION HAZARD	Oil/water contamination from the air line.	Fire in tank.	Separation, drying and filtering in air supply.		
IMPACT DROPPED LOAD HAZARD	Building collapse from external explosion (eg hydrogen storage).	Large release.	Concrete cladding on hydrogen tank. 40m separation.		
MAINTENANCE HAZARD	Tank emptying and entry.	Possible release and hazard to staff.	Procedure for tank checking and cleaning. Use water to clean and drain. Safety systems checked by government.		

HAZOP-PC 2.02 | Worksheet | Primatech Inc.

Company: BVM
Facility: CHLORINE PRODUCTION AND STORAGE

Node: 5
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Session: 1 18 01 93 Revision: 0 19 01 93 Dwg#: C2: Att. 2
Node: 5 STORAGE AND LIFTING (10,12)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
			Bursting disks checked against specification.		
	Liquid chlorine remaining in pipework.		Use of exhaust system.		
		Moderate chlorine release.	Steam heating.		
	Work on ventilation system.	Possible release to atmosphere if system not available.	Production stops.		Possible to have material in storage when ventilators not available.
THIRD PARTY ACTIVITY HAZARD	Railway activity. Flammable material present.	Fire in storage area leading to release.	None.	Check drainage of possible spills from railcars.	Used as a marshalling yard.
ESCALATION HAZARD	Explosive materials stored in another part of s'te.	Missile hazard.	300m separate from chlorine storage.		
	Peroxide plant nearby.			Check hazard from peroxide.	

HAZOP-PC 2.02 | Worksheet | Primatech Inc.

Company: BVM
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Session: 1 18 01 93 Revision: 0 19 01 93 Dwg#: C2: Att. 2
Node: 6 LOADING (11)
Parameter: HAZARD Intention:

DEVIATION	CAUSES	CONSEQUENCES	SAFEGUARDS	RECOMMENDATIONS	COMMENTS
FIRE HAZARD	External fires.	Catastrophic failure of railcar.			No overpressure protection on rail car tanks.
TOXIC RELEASE HAZARD	Drive away accident.	Large release.	Rail line blocked.	Check if railcars chocked.	
	Failure of connection to rail car.	As above	Klingerit valve protection (why was this brought up).		
	Failure to extract chlorine from pipeline.	Release of chlorine in 8-9m of pipeline.	Action to close valves to achieve flowback.		
	Valve leaks.	Small releases.	Checked by ammonium hydroxide		Apparently no check of valve sealing before disconnection.
	Drum/cylinder failure.	Moderate chlorine release.	Checked every 2 years for wall thickness and cleaned by water.		
	Flexible pipe failure.	Moderate chlorine release.	Changed at 3 month intervals.		No documented check of hose change-out.
	Valve leaks on pipe.	As for other valve leaks.			
CONTAMINATION HAZARD	Residue material in cylinders/drums.	Cylinder/drum if reactions.	Checked for weight. If water present handed to govt. If chlorine present cylinder is re-used.	Check procedure.	Presence of chlorine is checked by connecting to exhausting system, if not extracted it is not chlorine. Procedure assumes either chlorine or water.
	Flexible pipe contamination.	Possible reactions.	Cleaned with compressed air at each use.		
IMPACT DROPPED LOAD HAZARD	Valve or drum or cylinder failure on dropping during lifting.		Valves of drums/cylinders protected during storage but not during lifting.		Covers on drums apparently not always used.
	Exposed pipework in lifting area broken by drums.	Moderate chlorine release.	Not in vehicle traffic area, but could otherwise happen during lifting operations.		
MAINTENANCE HAZARD	Overfilling of cylinders/drums.	Possible failure of drum or cylinder on temperature increase.	Daily checking of weight scales.		
ESCALATION HAZARD	Fire in storage area.	Failure of drums or cylinders.	Storage limited to 25-30 drums and 200 cylinders.		Check fire protection in storage area.
CHLORINE UNLOADING HAZARD.		Chlorine release		Check operation of system during unloading (not designed for this).	

E2: Attachment 3

Hazard Overview (the small columns are categories: L, likelihood; SM, harm to man; SE, harm to the environment)

No	Hazard	Cause	Safeguards	Consequences	L	SM	SE	Comment	Potential Major Accident?
1	Exposure to chlorine in electrolysis rooms	Process leaks and upsets	Extraction to hypo plant, canister respirators	Occupational exposure to chlorine	B	B	A	Consider better wind indications, escape instructions and provision of compressed air breathing apparatus	No - for major chlorine leaks see below.
2	Exposure to mercury	Spillage leading to contamination and inhalation		Worker exposure to mercury	A	B	A	Consider sealing and washing of floor, improved procedures for removing amalgam blockages, use of "clean" and "dirty" areas	No
3	Magnetic fields	High currents in electrolysis room		Affects heart pacemakers	C	C	A	Consider barring employees and visitors with pacemakers from high current areas	No
4	Hydrogen fire or explosion associated with gasholder	Ignited leaks	Concrete containment and use of electrically protected equipment	Multiple injuries or fatalities	D	D	A	Consider improved control of ignition sources (introduced by visitors) and water seal heating	Yes - however this is not considered further since the hydrogen inventory is not sufficient to trigger Seveso upper tier requirements
5	Falling hazard from railcar	Human error		Single injury or fatality	C	B	A	Consider provision of better fall protection	No
6	Electrocution hazard	Entry to rectifier cabinets		Injury or death of worker or unauthorised person	C	C	A	Consider introduction of permit to work system and locks for electrical cabinets	No
7	Moving machinery hazard	Incomplete machine guards in compressor room		Serious worker injury or death	C	C	A	Consider improvements to machinery guards	No
8	Ultra-violet hazard	Exposure from hydrogen-in-chlorine testing procedure in compressor room	Light faces wall	Occupational exposure to ultraviolet light	A	B	A	Consider improved system to eliminate personal exposure	No

9	Major pipework release of gaseous or liquid chlorine	Impact, overpressure, corrosion, support failure, maintenance, operator error, introduction of reactive materials, etc	Engineering control, inspection and testing. Extraction to hypo plant. Shutdown of production on compressor failure	Potential to lead to of-site injuries or death	C	E	B	Consider improved operational procedures, provision of improved pipework support, improved engineering standards, also improved breathing apparatus, as above, chlorine detection equipment, and remote shut-off valves	Yes - see potential major accident 1
10	Release of chlorine from storage tanks	Impact, overpressure, corrosion, operator error, escalation (fire, explosion, ..)	Engineering control, inspection and testing. Extraction to hypo plant	Potential to lead to off-site injuries or death	E	E	C		Yes - see potential major accident 2
11	Release of liquid chlorine during filling of drums and cylinders	Operator error, pipework fatigue, drum rollaway, dropped drum	Operational procedures	Potential to lead to off-site injuries or death	C	E	B	Consider improved procedures and increased use of procedures, routing pipework away from lifting area, use of improved connecting hoses, prevention of simultaneous lifting and filling	Yes - see potential major accident 3
12	Release of chlorine during filling of railcar	Operator error, pipework fatigue, rollaway	Operational procedures	Potential to lead to off-site injuries or death	C	E	B	Consider improved procedures, and increased use of procedures. Also consider design changes to connecting pipe and to valves (so as to allow continuous venting)	Yes - see potential major accident 4
13	Failure of full railcar	Rail incident, operator error during filling, escalation of fire or explosion, corrosion	Design and inspection	Potential to lead to off-site injuries or death	E	E	C	Consider improvements to management and engineering control of railcars	Yes - see potential major accident 5
14	Environmental pollution by mercury	Major accident in cell room leading to release of mercury to drains	Interceptor system	Environmental mercury poisoning	D	A	C	Consider improved management of mercury, see above. Consider carrying out mercury mass balance	Yes - but not considered further in this report as the drainage system lies outside the scope

15	Hydrogen-chlorine explosion	Increase in hydrogen content of chlorine during processing due to impurities (this reaction is very sensitive to ignition in some concentrations). This is a particular hazard during start up	Hourly monitoring both in cellrooms and compressor room. Availability of hypo plant to absorb production	Could cause local injury and death Could also lead to off-site effects if there is a major chlorine release	C D	C E	A B	Consider process alterations, or improved quality of feedstock to reduce or eliminate hazard	Yes, in case of chlorine release, but this is included in major accidents 1-5 above
16	Environmental pollution by bulk chemicals	Fire water run-off or possible other major accident	Interceptor system	Could cause major short term effect	D	A	C		Not considered further but an assessment over the site of the fire water run-off potential should be considered
17	Hydrogen fire or explosion in cell room	Leak with ignition due to maintenance or other activities		Local injury or death	B	B	A	Consider improved containment of hydrogen and control of potential ignition sources	No

E2: Attachment 4

Categorised Risk Evaluation

Risk matrix for harm to man

Likelihood Category						
	A		*2* *8*			
	B		*1* *17*			
	C		*5*	*3* *6* *7* *15a*		*9* *11* *12*
	D	*14* *16*			*4*	*15b*
	E					*10* *13*
	F					
		A	B	C	D	E
	Consequence category					

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Pipework Release			

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Calculation of pipework release frequency*			*4*	

Revision History

Date	Issue	Comments
19/2/93	1	First issue by SRD

Prepared by: A Garlick	Signature: A Garlick	Date: 27/2/93

DRAFT C

OUTLINE SAFETY DOCUMENT	E3
POTENTIAL ACCIDENT ASSESSMENT	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	2

NUMBER: 1	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: Chlorine		
POTENTIAL MAJOR ACCIDENT: Pipework Release		

Description

Description of the accident:

Failure of chlorine pipework leads to release of gaseous or liquid chlorine either in plant rooms or outside. Failure can be caused by impact, operator error, maintenance error, introduction of reactive material, collapse of pipework support, corrosion, or the effects of local fires or explosions, including internal hydrogen explosions.

Number of persons exposed to the accident:

Many thousand members of the public

Classification of the accident:

Toxic release

Description of on-site response:

As described in C2. Main procedure is donning of gas marks and attempted escape upwind.

Has the on-site response been specifically designed against this accident?

Yes

Description of off-site response:

Off-site emergency plan details not available to us.

Has the off-site response been specifically designed against this accident?

Not applicable

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			3
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Pipework Release			

Estimates of Likelihood

Categorised likelihood assessment

Category assigned: *C*

Reasons/data:

Considerable lengths of pipework, much poorly supported, or in vulnerable positions.

Generic frequency assessment

Basic generic frequency used:

$6x10^{-4}$ per year, release over 1 kg/s
$6x10^{-3}$ per year, releases under 1 kg/s

Reasons/data:

See Attachment 1

Effect of protection systems:

Releases assumed terminated in 30 mins.

Reasons/data:

No immediate protective systems. Source of leak will need to be identified, operator will have to don breathing equipment to isolate leak, and carry out procedure correctly.

Adjustment factor: *3*

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			4
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Pipework Release			

Reasons/data for adjustment:

We found several shortcomings in the safety management at BVM (see Section D), and in particular the standard of pipework appears to be poor, both in terms of joints and engineering (see Section E2: Attachment 1). Therefore a factor approaching the maximum which might be used in the UK to account for this is applied.

Detailed systems analysis

Not applicable

Estimates of Consequences

Categorised consequence assessment

Category assigned: *E*

Reasons/data:

Releases over 1 kg/s would have the potential to be lethal at ranges of several hundred metres. There is domestic housing within such ranges.

Detailed consequence assessment

A typical release size of 2 kg/s for 1800 s, is chosen. Based on CRUNCH runs the length of the plume within which the HSE dangerous dose (60 ppm for a duration of 30 mins) is exceeded and the maximum plume width are as follows:

Weather	*Downwind Distance*	*Maximum Half-Width*	*Distance to Maximum Width*
D5	*448 m*	*35 m*	*220 m*
F2	*1640 m*	*165 m*	*430 m*

The corresponding data for a dose of 300 ppm, which is the dose which will be fatal

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			5
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Pipework Release			

to approximately 50% of the population are:

Weather	*Downwind Distance*	*Maximum Half-Width*	*Distance to Maximum Width*
D5	*196 m*	*20 m*	*80 m*
F2	*568 m*	*125 m*	*260 m*

The results are for a liquid release, but a gaseous release gives similar figures.

Evaluation

Likelihood: *$2x10^{-3}$ per year*

Safety consequence:

Lethal concentrations of chlorine for 600 m downwind in adverse weather conditions, and UK "dangerous doses" for 1600 m downwind.

Environmental consequence:

Some local effects on plants etc, but not of significance compared to harm to man.

Overall risk:

See Section F

Opportunities for prevention:

Improved pipework engineering (better support, more consistent engineering, better protection from impact), less complex operations and improved procedures.

Opportunities for control:

Provision of remote cut-off systems.

OUTLINE SAFETY DOCUMENT POTENTIAL ACCIDENT ASSESSMENT			E3
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			6
NUMBER: 1	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Pipework Release			

Opportunities for mitigation:

Provision of improved emergency procedures, both on- and off-site, including escape cross-wind, visible and reliable wind indications at all points

See also Section D for potential improvements to emergency plans.

Actions proposed or to be taken:

Not applicable

E3(1): Attachment 1

Calculation of pipework release frequency

Several pipework sections contain chlorine under pressure all or some of the time. Each has been estimated by plant personnel for length, diameter and number of flanges.

1 Gaseous chlorine between compressors and condensers

This consists of around 80 m of pipework with diameter between 50-100 mm, containing about 50 flanges.

Based on the generic data in the guidance the following frequencies might be experienced:

Guillotine failure:	80 x 5e-7 = 4e-5 pa
25 mm diameter hole:	80 x 5e-6 = 4e-4 pa
4 mm diameter hole:	80 x 1e-5 = 8e-4 pa
Flange leak (<17 mm equiv diam):	50 x 4e-6 = 2e-4 pa

The equivalent diameter of a flange leak is based on an assumed seal thickness of 3 mm and 4 bolts per flange.

The guillotine break is assumed to release chlorine at the production rate (3 kg/s) whereas the smaller holes give releases of order 0.5 kg/s (25 mm and flange leak) and 0.03 kg/s (4 mm) based on the CIA nomograph method assuming a pressure of 3 bar, ignoring pipework losses.

2 Liquid chlorine between condensers and storage tanks

This consists of around 120 m of pipework with diameter between 20-25 mm, containing about 50 flanges.

Based on the generic data in the guidance the following frequencies might be experienced:

Guillotine failure:	120 x 1e-6 = 1.2e-4 pa
4 mm diameter hole:	120 x 1e-5 = 1.2e-3 pa
Flange leak (about 8 mm equiv diam):	50 x 4e-6 = 2e-4 pa

Again the equivalent diameter of a flange leak is based on an assumed seal thickness of 3 mm and 4 bolts per flange.

The guillotine break is assumed to release chlorine at the production rate (3 kg/s) whereas the smaller hole gives releases of less than 0.3 kg/s. The flange leak may give a release over 1 kg/s.

3 Gaseous chlorine in recycle from storage to compressor

This consists of around 95 m of pipework with diameter 32 mm, containing about 40 flanges.

If this pipework fractures, and it is not isolated there can be a release from the storage tank driven by the evaporation rate from the tank. Such releases are ignored in this study since they are judged not to make a significant contribution to risk compared with other releases.

4 Liquid chlorine between storage tanks and loading faciiities

This consists of around 140 m of pipework with diameter of 20 mm, containing about 60 flanges.

This pipework is not used all the time (though when not in use, it is not clear that it is isolated). Therefore a factor of 30% is applied to the frequencies. Based on the generic data in the guidance the following frequencies might be experienced:

Guillotine failure:	140 x 0.3 x 1e-6 = 4e-5 pa
4 mm diameter hole:	140 x 0.3 x 1e-5 = 4e-4 pa
Flange leak (8 mm equiv diam):	60 x 0.3 x 4e-6 = 7e-5 pa

Again the equivalent diameter of a flange leak is based on an assumed seal thickness of 3 mm and 4 bolts per flange.

The guillotine break is assumed to release chlorine at a rate of several kg/s whereas the smaller hole gives releases of less than 0.3 kg/s. The flange leak may give a release over 1 kg/s.

5 Liquid chlorine between storage tanks and evaporator

This consists of around 110 m of pipework with diameter of 20 mm, containing about 40 flanges.

This pipework is not used all the time, only for feeding the organics plant and HCl production if there is insufficient feed from the compressor. Therefore a factor of 10% is applied to the frequencies. Based on the generic data in the guidance the following frequencies might be experienced:

Guillotine failure:	110 x 0.1 x 1e-6 = 1e-5 pa
4 mm diameter hole:	110 x 0.1 x 1e-5 = 1e-4 pa
Flange leak (8 mm equiv diam):	40 x 0.1 x 4e-6 = 1.6e-5 pa

Again the equivalent diameter of a flange leak is based on an assumed seal thickness of 3 mm and 4 bolts per flange.

The guillotine break is assumed to release chlorine at a rate of several kg/s whereas the smaller hole gives releases of less than 0.3 kg/s. The flange leak may give a release over 1 kg/s.

6 Gaseous chlorine between evaporators and organics plant

This consists of around 300 m of pipework with diameter 100 mm, containing about 35 flanges.

This pipework is not used all the time. However, we were told that about 5% of total production goes to the organics plant at a flow rate of 0.3 te/hr - about 15% of average production rate. There a factor of 0.3 only is used for this. Based on the generic data in the guidance the following frequencies might be experienced:

Guillotine failure:	300 x 0.3 x 5e-7 = 5e-5 pa
25 mm diameter hole:	300 x 0.3 x 5e-6 = 5e-4 pa
4 mm diameter hole:	300 x 0.3 x 1e-5 = 1e-3 pa
Flange leak (17 mm equiv diam):	35 x 0.3 x 4e-6 = 4e-5 pa

The equivalent diameter of a flange leak is based on an assumed seal thickness of 3 mm and 4 bolts per flange.

It is not clear what pressure conditions are experienced in this pipework. Therefore it is pessimistically assumed that the guillotine break will release chlorine at over 1 kg/s (though the apparent transport rate is only 10% of this) whereas the smaller holes give releases less than this.

7 Gaseous chlorine between evaporators/compressors and HCl plant

This consists of around 100 m of pipework with diameter between 100-125 mm, containing about 20 flanges.

This pipework appears to be used most of the time, and so no allowance is made for non use. Based on the generic data in the guidance the following frequencies might be experienced:

Guillotine failure:	100 x 5e-7 = 5e-5 pa
25 mm diameter hole:	100 x 5e-6 = 5e-4 pa
4 mm diameter hole:	100 x 1e-5 = 1e-3 pa
Flange leak (<20 mm equiv diam):	20 x 4e-6 = 8e-5 pa

The equivalent diameter of a flange leak is based on an assumed seal thickness of 3 mm and 4 bolts per flange.

It is not clear what pressure conditions are experienced in this pipework. Therefore, as above, it is assumed that the guillotine break will release chlorine at over 1 kg/s (roughly the transport rate) and that the smaller holes will give releases less than this.

Other pipework

In addition there is chlorine under negative pressure in the pipework between electrolysis and the compressors, and in the pipework leading to the hypo plant. In the case of the former, failure of this pipework could lead to a release of the order of the production rate (3 kg/s). We noted that the pipe leading into the compressor room is unprotected, and this is also a potential release. However, we did not collect data on pipelengths for these pipes. These releases are ignored since they will not make a major difference to the frequencies estimated already.

Total frequencies

The frequencies are binned for each release into those which give rise to releases above and below 1 kg/s. This reflects the categories which will be used for consequence assessment.

Although many of these releases will happen inside the buildings, this will not have a major effect on releases to the environment since the buildings are not sufficiently sealed to. The frequencies in the following table are therefore used in the remainder of the assessment.

Pipe	**< 1 kg/s**	**> 1 kg/s**
1	1.4e-3	4e-5
2	1.2e-3	3.2e-4
3	-	-
4	4e-4	1.2e-4
5	1e-4	3e-5
6	1.5e-3	5e-5
7	1.6e-3	5e-5
Total	**6e-3**	**6e-4**

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production Storage and Shipment of Chlorine at BVM			1
NUMBER: 2	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Storage Vessel Release			

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Calculation of storage tank release frequency*			*1*	

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: A Garlick	Signature: A Garlick	Date: 27/2/93

DRAFT C

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production Storage and Shipment of Chlorine at BVM			2
NUMBER: 2	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Storage Vessel Release			

Description

Description of the accident:

Release of chlorine from storage tanks. This could be caused by overpressure, impact, corrosion, operator error, or as a result of a fire in the storage area or by missiles generated by accidents elsewhere on the plant. The failure mode can either be catastrophic, or a hole above or below the liquid chlorine level.

Number of persons exposed to the accident:

Many thousand members of the public, especially if there is a catastrophic release.

Classification of the accident:

Toxic release

Description of on-site response:

As described in C2. Main procedure is donning of gas masks and attempted escape upwind. Presumably some activity takes place to transfer the chlorine from the failed tank - this has not been looked at in detail.

Has the on-site response been specifically designed against this accident?

Yes

Description of off-site response:

Off-site emergency plan details not available to us.

Has the off-site response been specifically designed against this accident?

Not applicable

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production Storage and Shipment of Chlorine at BVM			3
NUMBER: 2	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Storage Vessel Release			

Estimates of Likelihood

Categorised likelihood assessment

Category assigned: *E*

Reasons/data:

> *The storage tanks appear to be well managed and regularly inspected by the authorities, though we have not checked this point.*

Generic frequency assessment

Basic generic frequency used:

> *$8x10^{-6}$ per year, instantaneous release of 20 te of chlorine*
> *$5x10^{-5}$ per year, continuous release of over 1 kg/s of chlorine*
> *(Note that $3x10^{-5}$ per year of this is large releases of over 10 kg/s)*
> *$2x10^{-4}$ per year, continuous releases of under 1 kg/s*

Reasons/data:

> *See Attachment 1*

Effect of protection systems:

> *Continuous releases assumed terminated in 30 mins.*

Reasons/data:

> *Although this is the same assumption as for accident 1 it is a little optimistic by comparison, since it will be a more complicated operation to identify the problem and transfer the liquid chlorine - if this possible. However, the 30 min assumption is consistent with UK practice in this area.*

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production Storage and Shipment of Chlorine at BVM			4
NUMBER: 2	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Storage Vessel Release			

Adjustment factor: *1*

Reasons/data for adjustment:

In the UK credit would be given for the good standard of tank management - say a factor of 0.5. However, the potential for external events to cause tank failure (for example no control of flammable materials in the tank room) means that no adjustment will be made.

Detailed systems analysis

Not applicable

Estimates of Consequences

Categorised consequence assessment

Category assigned: *E*

Reasons/data:

The catastrophic releases have the potential to be lethal at ranges over 1 km. Many thousands of people live within this range.

Detailed consequence assessment

The continuous releases over 1 kg/s are modelled in the same way as for accident 1. (This is somewhat optimistic for releases over 10 kg/s.) The catastrophic release is conservatively modelled by the 40 te release discussed in accident 5. It is not anticipated that this will make significant differences in the results, given the very approximate nature of the risk assessment.

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production Storage and Shipment of Chlorine at BVM			5
NUMBER: 2	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Storage Vessel Release			

Evaluation

Likelihood: *$8x10^{-6}$ per year, catastrophic release*
$5x10^{-5}$ per year, continuous release

Safety consequence:

For the continuous release see accident 1; for the instantaneous release, lethal concentrations may be experienced up to 2 km downwind in unfavourable weather and the dangerous dose out to 10 km.

Environmental consequence:

Some local effects on plants etc, but not of significance compared to harm to man.

Overall risk:

See Section F

Opportunities for prevention:

Better control of flammable material and ignition sources in storage areas.

Opportunities for control:

Could consider provision of remote operated system for tank emptying.

Opportunities for mitigation:

Storage room doors sn ıld be kept shut at all times. Performance of the extraction system should be checked. See also Section D for potential improvements to emergency plans.

Actions proposed or to be taken: *Not applicable*

E3(2): Attachment 1

Calculation of Storage Tank Release Frequency

The generic frequencies given in the guidance are:

Catastrophic failure:	4 x 4e-6 = 1.6e-5 pa
50 mm diameter hole:	4 x 5e-6 = 2e-5 pa
25 mm diameter hole:	4 x 5e-6 = 2e-5 pa
13 mm diameter hole:	4 x 1e-5 = 4e-5 pa
6 mm diameter hole:	4 x 4e-5 = 1.6e-4 pa

Catastrophic failure

In principle a number of scenarios should be calculated, depending on the level of the tank on failure. Here we consider only two cases. The first is failure of a full tank, leading to an instantaneous release of 20 te of chlorine to the atmosphere. We consider that catastrophic failure of this size will not be significantly mitigated by the building. The other case assumes a nearly empty tank (containing only a few tonnes) and this is ignored since it will not contribute significantly to risk compared with the other releases considered. Thus an instantaneous release of 20 te of chlorine with a frequency of 8e-6 per year is assumed.

Vessel holes

It is assumed that 50% of the vessel holes lie above the liquid level leading to a gaseous release. 50% are below with a liquid release. Using the nomograph in Attachment 1 of accident 1 and an assumed pressure of 3 bar the following release rates are estimated:

Size (mm)	**Gas (kg/s)**	**Liquid (kg/s)**	**f(<1 kg/s)**	**f(>1 kg/s)**
50	3	>10		2e-5
25	0.6	>10	1e-5	1e-5
13	0.2	3	2e-5	2e-5
6	0.03	0.6	1.6e-4	
		Totals	**2e-4**	**5e-5**

The table also shows the corresponding frequencies of release of above and below 1 kg/s.

Releases below 1 kg/s are likely to be controlled by the extract system provided to remove leaking chlorine to the hypo plant. Larger releases may not be controlled in this way, especially as the doors of the storage area are normally left open.

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 3	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Release from Drum/Cylinder Filling			

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Calculation of release frequencies for drum and cylinder filling operations*			2	

Revision History

Date	Issue	Comments
16/2/93	1	First issue by SRD

Prepared by: A Garlick	Signature: A Garlick	Date: 27/2/93

DRAFT C

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: 3	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Release from Drum/Cylinder Filling			

Description

Description of the accident:

This could be due to leaks or fractures of the loading pipework caused by drum rollaway or fatigue of the transfer pipe. An additional cause would be catastrophic failure of a drum: dropped while being lifted, overfilled, or overpressure due to reactions with contaminants. Damage to pipework caused by drum lifting is considered in accident 1. A further hazard would be explosions caused by contaminated drums or cylinders. This has been experienced - see section C3.

Number of persons exposed to the accident:

Releases from the catastrophic failure of a drum could expose many thousand members of the public.

Classification of the accident:

Toxic release

Description of on-site response:

As described in C2.

Has the on-site response been specifically designed against this accident?

Yes

Description of off-site response:

Off-site emergency plan details not available to us.

Has the off-site response been specifically designed against this accident?

Not applicable

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			3
NUMBER: 3	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Release from Drum/Cylinder Filling			

Estimates of Likelihood

Categorised likelihood assessment

Category assigned: *C*

Reasons/data:

Considerable number of loading operations per year, using fallible technology.

Generic frequency assessment

Basic generic frequency used:

$1x10^{-3}$ per year, catastrophic drum failure
$4.5x10^{-2}$ per year, transfer pipe failure

Reasons/data:

See Attachment 1

Effect of protection systems:

Continuous releases assumed terminated in 30 mins.

Reasons/data:

In this case the standard UK figure is probably pessimistic since releases from pipe fractures can probably be easily and quickly isolated. However, since these releases are not considered as contributing to the risk, this is not important.

Adjustment factor:

Reasons/data for adjustment:

OUTLINE SAFETY DOCUMENT POTENTIAL ACCIDENT ASSESSMENT	E3
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	4
NUMBER: 3 ISSUE: 1 DATE: 16/2/93	
SUBSTANCE: Chlorine	
POTENTIAL MAJOR ACCIDENT: Release from Drum/Cylinder Filling	

Incorporated in the assessment - see Attachment 1.

Detailed systems analysis

No applicable

Estimates of Consequences

Categorised consequence assessment

Category assigned: *E*

Reasons/data:

The catastrophic 1 te release would have the potential to be lethal at ranges of several hundred metres. There is domestic housing within such ranges.

Detailed consequence assessment

The guillotine failure of the transfer pipes is ignored - see Attachment 1. The consequences of a sudden release of 1 te chlorine following catastrophic drum failure is modelled using the DENZ code. The plume is described as follows for the HSE "dangerous dose":

Weather	*Downwind Distance*	*Upwind Distance*	*Maximum Half-Width*	*Distance to Maximum Width*
D5	*602 m*	*13 m*	*77 m*	*160 m*
F2	*1443 m*	*85 m*	*160 m*	*130 m*

The corresponding data for a dose corresponding to five times the concentration, which is the lethal dose for 50% of the population are:

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			5
NUMBER: 3	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Release from Drum/Cylinder Filling			

Weather	*Downwind Distance*	*Upwind Distance*	*Maximum Half-Width*	*Distance to Maximum Width*
D5	*209 m*	*13 m*	*66 m*	*85 m*
F2	*355 m*	*85 m*	*135 m*	*56 m*

Evaluation

Likelihood: *10^{-3} per year*

Safety consequence:

to be added.

Environmental consequence:

Some local effects on plants etc, but not of significance compared to harm to man.

Overall risk:

See Section F

Opportunities for prevention:

Increased use of procedures for loading cylinders and drums. Rerouting pipework away from exposed areas. Review of safety management of lifting operation. Review of design and inspection of drums.

Opportunities for control:

None suggested.

Opportunities for mitigation:

See accident 1.

OUTLINE SAFETY DOCUMENT	E3
POTENTIAL ACCIDENT ASSESSMENT	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	6

NUMBER: 3	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: Chlorine		
POTENTIAL MAJOR ACCIDENT: Release from Drum/Cylinder Filling		

Actions proposed or to be taken:

Not applicable

E3(3): Attachment 1

Calculation of release frequencies from drum and cylinder filling operations

Two types of accident are considered. One is pipework fracture during loading; the other is catastrophic failure of a full drum, for example if dropped during a lifting operation.

Transfer pipe failure

13000 cylinder and 2000 drum loadings are performed each year. This implies a fracture frequency of:

15000 x 3e-6 = 4.5e-2 pa,

on the basis of the generic frequencies referenced in the guidance.

This is high - near the level where it could be falsified on the basis of past experience, since it predicts failure every 20 years. No such events were found in the five year period discussed in Section C3, and a further survey could be carried out.

The release rate of these guillotine failures is estimated at roughly 0.3 kg/s assuming a driving pressure of 3 bar. This is less than the level of 1 kg/s at which we consider off-site effects.

It is not clear whether this is correctly estimated since it would take a long time to fill a drum (about an hour) at this rate. However a non-flashing release rate at this pressure and for this pipe is around 1 kg/s which is probably closer to the filling rate. However it is apparent that these rates will put considerable pressure on the filling staff when an average of 10 drums per working day have to be filled. It appears to be easily possible to carry out lifting operations at the same time as filling is going on.

Catastrophic drum failure

There are 4000 lifting operations per year with full drums (2000 drums per year, each with 2 movements). It is expected that serious drops would occur relatively frequently, perhaps every few years. However it is more difficult to estimate whether this would lead to catastrophic failure.

Using the generic data for catastrophic failure of a pressure vessel, and assuming 30 full cylinders gives a figure of:

30 x 4e-6 = 1.2e-4 pa.

Assuming the lifting operation places greater stress on the drums and increasing this figure by an order of magnitude gives 1e-3 per year. This corresponds to a chance of 2.5e-7 of catastrophic failure per lifting operation (and something less than 1e-2 per serious drop). These figures appear reasonable and a frequency of 1e-3 per year for catastrophic failure of a full chlorine drum is adopted. This figure is intended to envelope other cause of catastrophic drum failure, including overfilling and reaction with contaminants.

A much fuller study, taking account both of the drop frequency, and the materials aspects of the drums to determine the fracture probability on dropping to estimate better frequencies than these.

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 4	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Release from Railcar Filling			

Attachment List

No	Title	ID	Issue	No Pages	Comment
	None				

Revision History

Date	Issue	Comments
16/2/93	1	First release by SRD

Prepared by: A Garlick	Signature: A Garlick	Date: 17/2/93

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OUTLINE SAFETY DOCUMENT		E3
POTENTIAL ACCIDENT ASSESSMENT		
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM		2
NUMBER: 4	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: Chlorine		
POTENTIAL MAJOR ACCIDENT: Release from Railcar Filling		

Description

Description of the accident:

Operator error while filling (or unloading) may lead to pipework releases in different areas of the plant. The focus here is failure of the connecting pipe to the railcar, due to maloperation or movement of the railcar.

Number of persons exposed to the accident:

Members of the public live within the potential hazard range of this incident

Classification of the accident:

Toxic release

Description of on-site response:

As described in C2.

Has the on-site response been specifically designed against this accident?

Yes, this type of incident is covered (chlorine release) though it is not known if this specific incident is.

Description of off-site response:

Off-site emergency plan details not available to us.

Has the off-site response been specifically designed against this accident?

Not applicable

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			3
NUMBER: 4	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Release from Railcar Filling			

Estimates of Likelihood

Categorised likelihood assessment

Category assigned: *C*

Reasons/data:

This operation is dependent on properly carried out procedures, and the equipment (especially the connecting pipe) is fairly crude.

Generic frequency assessment

Basic generic frequency used:

$4x10^{-4}$ per year

Reasons/data:

Generic frequency is $7.5x10^{-6}$ per operation and 50 operations per year.

Effect of protection systems:

Release assumed terminated in 30 mins.

Reasons/data:

This is the standard time for use in the UK, though this failure mode is probably anticipated.

Adjustment factor: *5*

Reasons/data for adjustment:

This is increased somewhat from accident 1 to account for the relatively greater *potential for operator error, compared for the mean for pipework failures.*

Detailed systems analysis

Not applicable

Estimates of Consequences

Categorised consequence assessment

Category assigned: *E*

Reasons/data:

Releases from a guillotine failure of a connecting pipe can be anticipated as having lethal effects several hundred yards away. There are residential areas within such ranges.

Detailed consequence assessment

The release rate for a guillotine failure of the pipework is estimated to be in the range 2-3 kg/s, assuming a pad pressure of 8 bar. This would be not much reduced from the fill flow rate because at higher pad pressures the effect of flashing is reduced.

Consequently, for the purposes of this assessment, the effects are expected to be the same as for the 2 kg/s release considered for accident 1.

Evaluation

Likelihood: $2x10^{-3}$ *per year*

Safety consequence:

Lethal concentrations of chlorine for 600 m downwind in adverse weather conditions, and UK "dangerous doses" for 1600 m downwind.

OUTLINE SAFETY DOCUMENT	E3
POTENTIAL ACCIDENT ASSESSMENT	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	5

NUMBER: 4	ISSUE: 1	DATE: 16/2/93
SUBSTANCE: Chlorine		
POTENTIAL MAJOR ACCIDENT: Release from Railcar Filling		

Environmental consequence:

Some local effects on plants etc, but not of significance compared to harm to man.

Overall risk:

See Section F

Opportunities for prevention:

Improved use of procedures (for example putting into use the procedure which was written for the study). Improved pipework for the railcar connection and improved control of reactive materials (we saw a grease tub at the railcar filling point).

Opportunities for control:

Provision of remote cut-off system.

Opportunities for mitigation:

See accident 1. It should be checked that the on-site emergency plan deals specifically with this incident.

Actions proposed or to be taken:

Not applicable

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			1
NUMBER: 5	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Railcar Failure			

Attachment List

No	Title	ID	Issue	No Pages	Comment
	None				

Revision History

Date	Issue	Comments
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Prepared by: A Garlick	Signature: A Garlick	Date: 27/2/93

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OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			2
NUMBER: 5	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Railcar Failure			

Description

Description of the accident:

It is possible for several types of failure to occur to the railcar. Here the focus is on catastrophic failure modes since this is potentially the most serious credible accident. This could be caused by maloperation (overfilling), material failure (possibly corrosion induced), or external effects such as a rail accident, missile penetration or fire engulfment.

Number of persons exposed to the accident:

Many thousand members of the public

Classification of the accident:

Toxic release

Description of on-site response:

As described in C2.

Has the on-site response been specifically designed against this accident?

Yes - for chlorine releases. It should be checked that it specifically covers this incident, especially the case of fire engulfment since the fire control measures need to be prescribed, and there is a case for precautionary evacuation.

Description of off-site response:

Off-site emergency plan details not available to us.

Has the off-site response been specifically designed against this accident?

Not applicable

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			3
NUMBER: 5	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Railcar Failure			

Estimates of Likelihood

Categorised likelihood assessment

Category assigned: *E*

Reasons/data:

There is apparently good design and inspection of railcars, so the incident is unlikely, though not "incredible".

Generic frequency assessment

Basic generic frequency used:

$6x10^{-6}$ per year, for catastrophic failure of a full wagon

Reasons/data:

It appears there is considerable local concern over the possibility of a full (40 te) railcar suffering catastrophic failure. A realistic estimate of the frequency of this event (the worst credible accident on the plant) would be complex.

Provided the thick-walled tank is well designed and inspected, it is likely to withstand most external events - slow speed rail incidents on-site (main-line crashes would be a further concern, but lie outside the scope of the study), missile generation by explosions on-site, etc.

This leaves events leading to internal overpressure, the importance of which is emphasised by the fact that - probably quite rightly - no overpressure protection for the vessel is provided. Failure could be caused by overfilling and warming up, or by fire engulfment (due for example to a motor spirit spill on the adjoining railway). In the latter case considerable time would be available for fire control and precautionary evacuation, if appropriate. There are a number of operational and design features to prevent overfilling, but the possibility of these being defeated exists.

However, failing a full study, the generic figures will be used. Assuming a full railcar is on site only 15% of the time, the failure frequency is:

$$0.15 \times 4x10^{-6} = 6x10^{-7} \text{ per year.}$$

Increasing this by a factor of 10 to account for the potential operator involvement and the chance of fire engulfment gives an assumed result of $6x10^{-6}$ per year. It should be emphasised that this is an approximate figure which should be backed up with a better estimate if this is considered important.

Effect of protection systems:

None.

Reasons/data:

Apart from the fire fighting requirement already noted, there is no protection from catastrophic events.

Adjustment factor:

Reasons/data for adjustment:

Included above

Detailed systems analysis

Not applicable

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			5
NUMBER: 5	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Railcar Failure			

Estimates of Consequences

Categorised consequence assessment

Category assigned: *E*

Reasons/data:

Major off-site effects could be experienced several kilometres downwind.

Detailed consequence assessment

The effects of a sudden release of 40 te of chlorine following catastrophic failure of a full railcar is modelled using the DENZ code. The plume is described as follows for the HSE "dangerous dose":

Weather	*Downwind Distance*	*Upwind Distance*	*Maximum Half-Width*	*Distance to Maximum Width*
D5	*2997 m*	*56 m*	*345 m*	*703 m*
F2	*10590 m*	*244 m*	*706 m*	*1073 m*

The corresponding data for a dose corresponding to five times the concentration, which is the lethal dose for 50% of the population are:

Weather	*Downwind Distance*	*Upwind Distance*	*Maximum Half-Width*	*Distance to Maximum Width*
D5	*1097 m*	*56 m*	*287 m*	*373 m*
F2	*2254 m*	*244 m*	*593 m*	*460 m*

OUTLINE SAFETY DOCUMENT			E3
POTENTIAL ACCIDENT ASSESSMENT			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			6
NUMBER: 5	ISSUE: 1	DATE: 16/2/93	
SUBSTANCE: Chlorine			
POTENTIAL MAJOR ACCIDENT: Railcar Failure			

Evaluation

Likelihood: *$6x10^{-6}$ per year*

Safety consequence:

Lethal concentrations of chlorine for over 2 km downwind in adverse weather conditions, and UK "dangerous doses" for 10 km downwind.

Environmental consequence:

Effects on plants etc - see E1, but not of significance compared to harm to man.

Overall risk:

See Section F

Opportunities for prevention:

Better management of the railcar on-site, including an improved system for filling which allows continuous venting. Check on design, inspection and testing of railcar. Hazard control on-site to minimise likelihood of railcar involvement in accidents.

Opportunities for control:

Review fire fighting plans for fires in vicinity of railcar.

Opportunities for mitigation:

Check adequacy of on- and off-site emergency plans for this event.

Actions proposed or to be taken:

Not applicable

OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	1

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Attachment List

No	Title	ID	Issue	No Pages	Comment
1	*Quantitative risk assessment*			*12*	

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Date	Issue	Comments
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OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	2

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Summary table of potential major accidents

Ref	Brief description	Likelihood	Consequence	Priority	Action
1	*Pipework chlorine release*	*C-D*	*See E3(1)*		*See conclusions for all*
2	*Storage tank chlorine release*	*E*	*See E3(2)*		
3	*Drum/cylinder filling point chlorine release*	*D*	*See E3(3)*		
4	*Railcar filling chlorine release*	*C-D*	*See E3(4)*		
5	*Catastrophic railcar failure chlorine release*	*E*	*See E3(5)*		
6	*Hydrogen fire/explosion*	*D*	*D*		
7	*Environmental pollution by mercury*	*D*	*C(env)*		

OUTLINE SAFETY DOCUMENT	F
CONCLUSIONS	
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM	3

NUMBER: N/A	ISSUE: 1	DATE: 16/2/93

Categorised Risk Evaluation

Risk matrix for harm to man

Risk matrix for harm to the environment

> *The matrix for harm to man is in Section E2, and that for the environment has not been prepared since there are few environmental issues in this study.*

Quantitative Risk Evaluation

> *See Attachment 1*

> *This gives a crude assessment of the individual and societal risks from the chlorine releases. Two dose levels are used; one is the HSE dangerous dose level, the other is the level which is fatal to around 50% of the population. The assessment shows risk levels which are high compared to standards discussed in the UK and it is recommended that a number of improvements to the process and its management are made before a more detailed and accurate quantitative risk assessment is made.*

Overall Risk Evaluation

Is the information supplied above complete?

> *The quantitative assessment covers only chlorine releases; the hydrogen accidents and mercury pollution have not been looked at in detail.*

> *More importantly they cover only the chlorine processes at the Illatos ut site. It is known that a number of other hazardous materials are used on the site; for example hydrogen fluoride, and those that led to the explosion in January 1992. However none of these would trigger a requirement for a safety notification under the Seveso Directive. It is likely also that a number of occupational health hazards are present associated with the other hazardous materials.*

> *Within 500 m of the Illatos ut site is another BVM facility at Ken utca and this would also need to be considered for possible interactions under the Seveso Directive. We*

do not know what processes or dangerous substances are present at Ken utca.

Are the measures which have been identified to prevent, control, mitigate and protect against major accidents adequate?

The activity of chlorine production, storage and shipment at BVM uses a process and equipment which .s extremely old, and as a consequence very dependent on correct operator actions. The activity itself is very hazardous, as evidenced by the large hazard ranges which arise from the worst conceivable accidents, and consequently needs careful management. The plant suffers from considerable under-investment over many years which means there are few automated functions for normal operation or safety intervention. Apart from this the legacy of the past appears to be a number of good management systems which do not, however, blend into a coherent whole, and which are not consistently applied. The safety culture of the plant staff is also a matter of concern as Hungarian culture generally adapts to a new commercial and social environment. This view is supported by the considerable number of incidents which have occurred over a five year period, particularly involving the failure of operators to behave as required. This is not surprising in view of the lack of detailed procedures for plant operation. In addition to this it is clear that although emergency plans have been prepared, they would not in fact operate as required in the event of a major incident.

Overall, then, there is much that can be done both to prevent, control and mitigate potential major accidents and to improve occupational health.

A number of measures have been identified in the course of this study. They are set out in detail under the records of the safety audit, Section D, the HAZOP and safety inspection, Section E2, and the risk assessment, Section E3. The main recommendations are repeated below.

OUTLINE SAFETY DOCUMENT			F
CONCLUSIONS			
INDUSTRIAL ACTIVITY: Production, Storage and Shipment of Chlorine at BVM			5
NUMBER: N/A	ISSUE: 1	DATE: 16/2/93	

Set out the measures which are suggested/planned such that major accidents will be further prevented, controlled, mitigated and protected against:

Some of the following recommendations involve expenditure on plant modifications, though none of them are on a major scale. Others provide significant increases in safety at relatively little cost. It was the intention of the study team to try and make proposals which are cost-effective, and which build on the good systems which are already in place.

(1) *Emergency planning: regular exercising of the emergency plan should take place; consideration should be given to an alarm system which differentiates between different types of events. Wind direction indications should be improved, and increased provisions of compressed air breathing apparatus made.*

(2) *Procedures should be used more widely and should be more specific in nature. The same applies to maintenance instructions. Both would be assisted by a valve numbering system.*

(3) *Requirements for environmental control should be improved and documented; in particular a mass balance study for mercury should be carried out to reduce environmental pollution from this source.*

(4) *A more formal approach to the design and modification process is required with the inclusion of hazard assessment and quality assurance.*

(5) *The plant safety management system should come under the current introduction of ISO 9000 quality systems.*

(6) *In view of the number of incidents involving operator error, the adequacy of operator training should be reviewed, as should the possibility of simplifying the process so that the scope for operator error is reduced.*

(7) *The effects of mercury contamination could be reduced by improved sealing of floor in cell rooms and the provision of "clean" and "dirty" areas.*

(8) *Personal safety improvements could be made in the following areas: fall protection on the railcar, machinery guards in the chlorine compressor room, exposure to UV*

light, electrocution hazards in the rectifier rooms, exposure of heart pacemakers to magnetic fields in the cell rooms.

(9) *Ways to reduce the risk of hydrogen explosions in the chlorine mixture should be sought by suitable adjustments to the process and/or feedstock.*

(10) *Improvements should be made to the standard of chlorine pipework, particularly in jointing and supporting. Rerouting should also be considered in the areas of: the railcar manifold, the suction pipe from the cell rooms and liquid chlorine feed in the drum/cylinder filling area. The standard of the semi-flexible connecting pipes used for filling of all kinds should be reviewed.*

(11) *Consideration should be given to changing the railcar design to allow continuous venting while filling is taking place.*

(12) *Consideration should be given to the provision of systems for chlorine detection and remotely shut-off of potential chlorine leaks.*

(13) *Consideration should be given to decreasing the exposure of the full railcar to hazards. The design, inspection and testing of the railcar should also be reviewed.*

(14) *Hazards resulting from the generation and storage of hydrogen should be reduced, including control of ignition sources (both in the cell rooms and in the storage area), prevention of leaks in the cell rooms, and consideration given to the possibility of heating the water seal on the storage tank.*

(15) *The availability and performance of the extraction system to the hypo plant should be reviewed, and consideration given to the provision of an expansion tank in the storage tank bursting disc system.*

Section F: Attachment 1

Quantitative Risk Assessment

1 Introduction

The information provided in Section E3 about potential major accidents involving chlorine releases is used to calculate individual and societal risk in the neighbourhood of the site.

Three typical releases were chosen for the purpose of detailed consequence calculations - a continuous release of 2 kg/s, and instantaneous releases of 1 te and 40 te. The shape of the plume from these releases was described using four simple parameters: the maximum distance downwind at which a certain dose is reached, the upwind distance, the crosswind distance, and the downwind distance at which the crosswind maximum is reached. This is done for two dose levels expressed in terms of the square of concentration time the exposure time. The first is the so-called "dangerous dose" used by the HSE in the UK for land-use planning purposes: 108,000 ppm^2 min. This is a level which might be fatal to the weakest members of the population - the very young or very old, or ill. The other dose level is one which is expected to be fatal to approximately 50% of the population and represents concentrations which are five times higher.

The geometrical parameters are used to generate a simple description of the plume shape - polar angle as a function of radius - which can be used to calculate individual risk and societal risk by spreadsheets. The method employed enables the individual risk to be calculated at any point in the vicinity of the plant. No allowance is made for escape from the plume.

If a population number is associated with each point it is possible to calculate societal risk. This estimates the frequency with which a given number of people are affected to the given dose level and is expressed in terms of an fN line. This is a graph on which the horizontal axis represents accident severity - in this case the number of people receiving a given toxic dose - and the vertical axis is the frequency with which an accident of that severity, or greater occurs.

2 Releases

The information given for the five accidents considered in detail in Section E3 can be represented in the following way:

Accident	40 te	1 te	2 kg/s
1 Pipework release			$2x10^{-3}$
2 Storage tank release	$8x10^{-6}$		$5x10^{-5}$
3 Drum/cylinder filling release		$1x10^{-3}$	
4 Railcar filling release			$2x10^{-3}$
5 Catastrophic railcar failure	$6x10^{-6}$		

Totals	**$1.4x10^{-5}$**	**$1x10^{-3}$**	**$4x10^{-3}$**
D5 frequency	$1.26x10^{-5}$	$9x10^{-4}$	$3.6x10^{-3}$
F2 frequency	$1.4x10^{-6}$	$1x10^{-4}$	$4x10^{-4}$

This table gives the annual frequency of each release, shows which accidents contribute to it, and how it breaks down into the two weather conditions used in this study as set out in Section C1. (This is probably somewhat pessimistic since many of the releases are associated with daytime operations when F2 weather conditions would be less likely to be present.)

The plume parameters (in metres) for each release are summarised in the following table:

Dose	**Parameter**	**40 te**		**1 te**		**2 kg/s**	
		D5	**F2**	**D5**	**F2**	**D5**	**F2**
HSE Dangerous Dose	Downwind distance	2997	10590	602	1443	448	1640
	Upwind distance	56	244	13	85	0	0
	Maximum half-width	345	706	77	160	35	165
	Position of maximum width	703	1073	160	130	220	430
Approximate LD50 dose	Downwind distance	1097	2254	209	365	196	568
	Upwind distance	56	244	13	85	0	0
	Maximum half-width	287	593	66	135	20	125
	Position of maximum width	373	460	85	56	80	260

3 Individual Risk

Using the windrose information provided in Section C1, the individual risk can be calculated. This number represents the annual frequency with which someone located at permanently at a particular point would receive a particular dose.

An array containing 79 points surrounding the chlorine plant was set up. It extends out to 1.6 km on a 400 m grid, but close to the plant is on a 100 m grid.

Figure 1 shows the risk of receiving the HSE dangerous dose, and Figure 2 shows the same focusing on the central area (it also has a line marking Hatar ut, the boundary of the nearest housing). The plant itself is centred on the (x=0,y=0) point. These figures show that within a kilometer of the plant the risk exceeds $1x10^{-5}$ per year and that it drops to 10^{-6} only outside a radius of 2 km. At the nearest inhabited point the risk of receiving a dangerous dose is around $5x10^{-4}$ per year.

The risk of receiving an LD50 dose is obviously much lower: around 10^{-7} per year at a radius of 1.5 km, and 10^{-4} per year at the nearest inhabited point.

It should be emphasised that these figures take no account of the effect of evacuation, or being indoors. Being indoors is always accounted for by the HSE in carrying out assessments, and this can reduce the risk considerably.

4 Societal Risk

Societal risk is calculated only for people within the 2 km hazard radius used by the local authorities. Approximately 75,000 people were estimated as being within this distance in Section C1 and Figure 5 shows a grid with approximately this number of people on it, estimated using the information presented there. These are split into 3 groups: the majority are the inhabitants of the low-rise housing to the South East of Hatar ut, but the grid also contains nearly 24,000 people in the high rise blocks between the plant and Ulloi ut and 5,000 people in the low rise housing around the junction of Gyali ut and Ecseri ut to the North North West. Figures 6 and 7 show the individual risk for each dose level on this grid.

The societal risk for the HSE dangerous dose is shown in Figure 8. This shows accidents with up to 200 people affected at a frequency of 10^{-3} per year and up to 2000 people at $2x10^{-4}$ per year. Accidents affecting more than 20,000 people occur with a frequency of under 10^{-6} per year.

For the LD50 dose, Figure 9, which gives a better representation of the number of fatalities which might be experienced, the 200 figure is experienced at less than 10^{-4} per year and 2000 at less than 10^{-5} per year. An accident with 10,000 people affected to this level is estimated to happen at the once in a million years level. This is due entirely to the 40 te release in F2 weather, and is consequently highly uncertain.

It is important to note that the consequences have been calculated at ground level. This is reasonable approximation for the low-rise housing, but would be questionable for the high rise housing, depending on the countermeasure strategy adopted.

5 Discussion

The risk assessment presented is a very basic one. It considers only 3 releases, two weather categories and two dose levels. This represents approximately the limit of what can be achieved using simple spreadsheet methods; more complex calculations need to be done using dedicated tools such as the HSE's RISKAT code another such package.

It serves to demonstrate the approximate risk levels based on the assumptions used for frequency and consequence in Section E3.

A number of risk issues are not considered. These include:

- the effect of countermeasures such as evacuation, or remaining indoors with windows and other sources of ventilation sealed;
- risks to traffic on passing roads, including the new motorway passing the Eastern end of the Illatos ut site;
- risks to non-residents such as the employees on neighbouring sites, and school children - the risk has been estimated including only residents (but assuming they are there all the time);
- societal risks have not included the workers on the site itself - these would undoubtedly swell the casualty figures.

All these effects could be taken into account, but this would not be useful at this stage of the risk assessment.

By most standards (for example those under discussion in the UK) these risks are high. This is not surprising given that people live relatively close to the site, and that the frequencies derived are high. The frequencies are high because the generic figures which have been used have been increased to account for the high potential for operator error and the lapses in the safety management we have observed in the plant. Credit has also not been given for the emergency plans which could reduce the risk levels if effective countermeasures are taken.

However, the frequencies are also very uncertain. They could be improved with more detailed analysis, but this is not appropriate at this stage. The recommendations which are made to improve safety levels will reduce the estimated event frequencies considerably. It would not be appropriate to carry out more detailed quantified risk assessments until further improvements in the management of safety have been made and shown to be effective. At that point the generic data would be more relevant and better quality more detailed studies could be carried out.

BVM Chlorine Plant

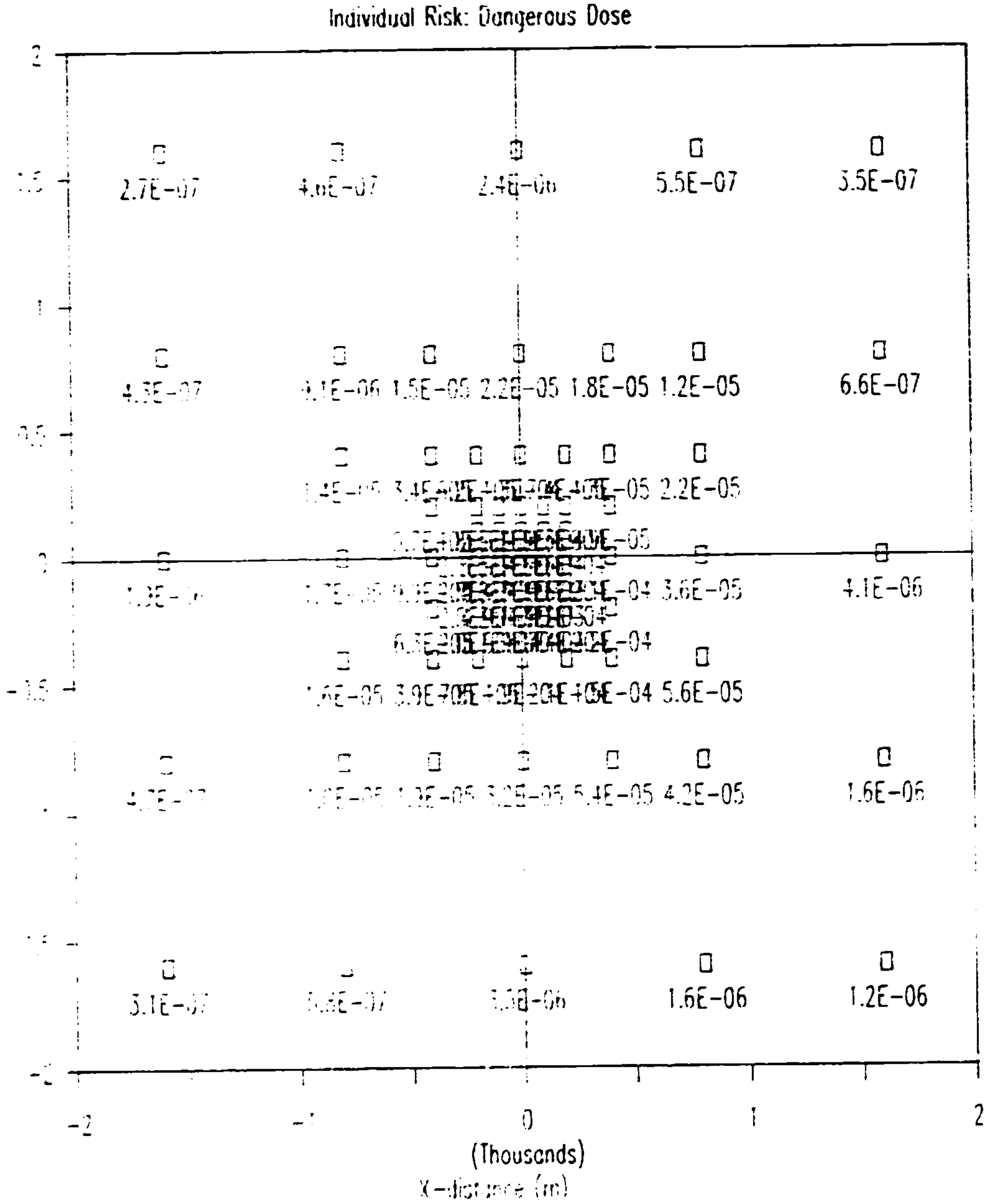


Fig 1

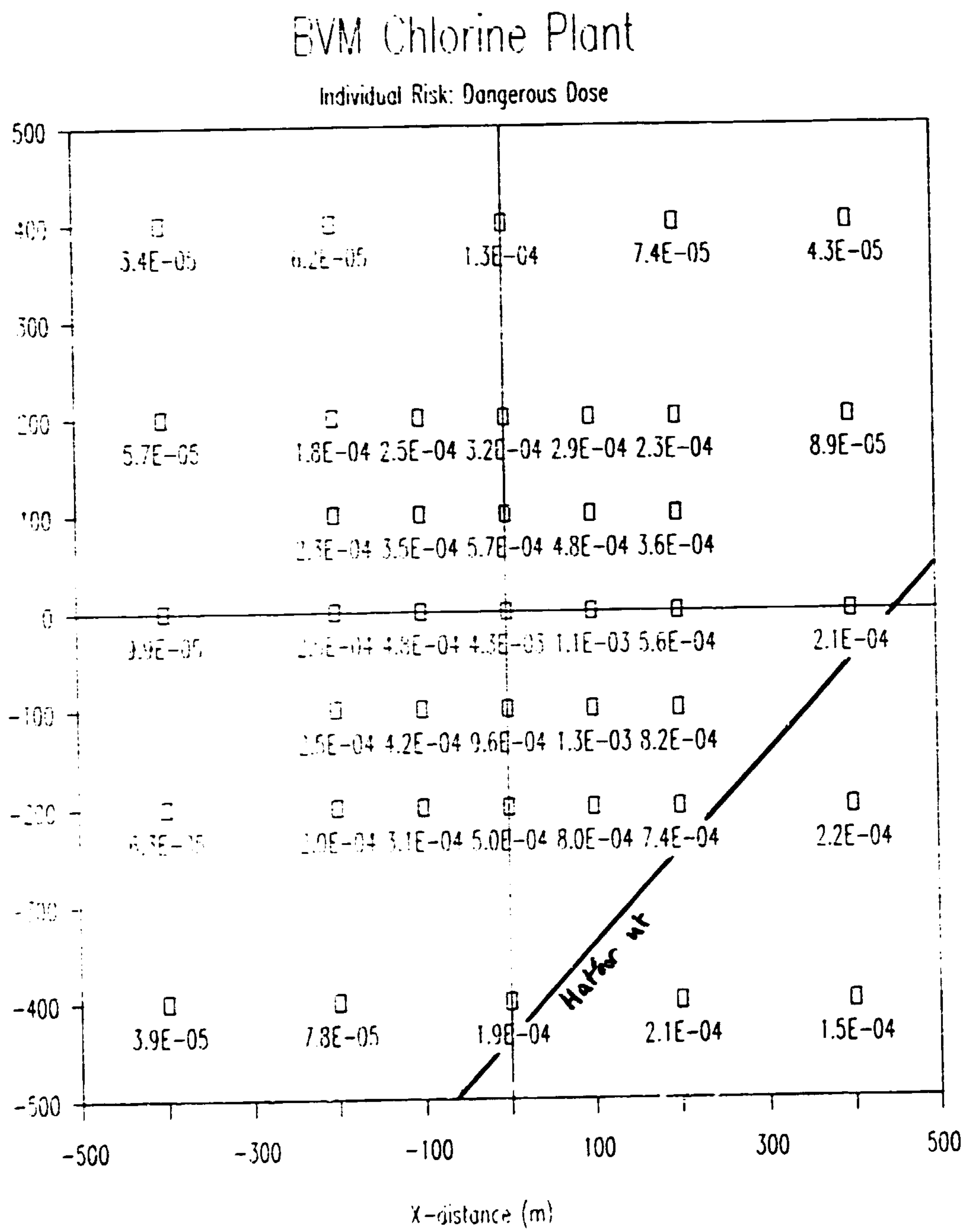
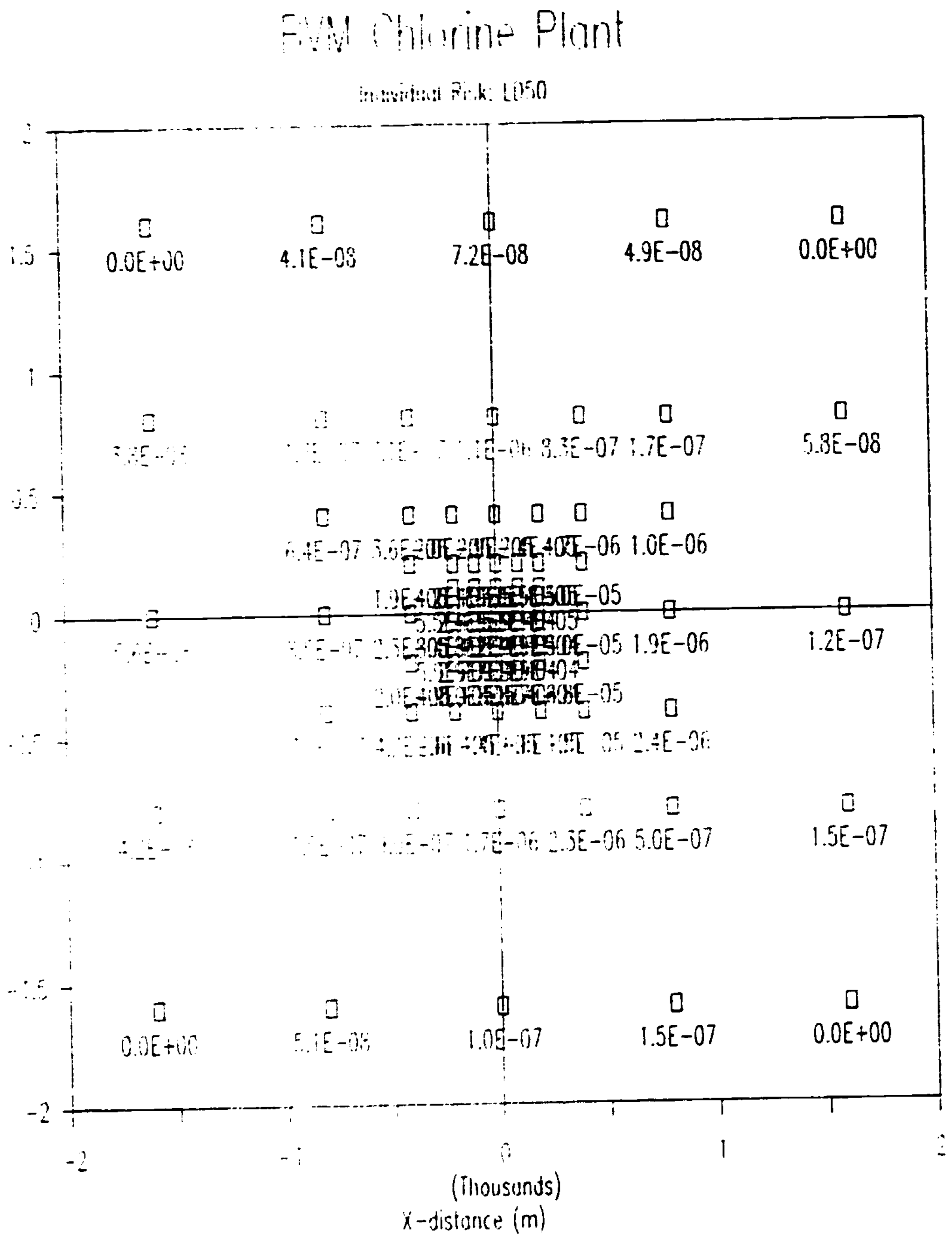

BVM Chlorine Plant
Individual Risk: Dangerous Dose
X-distance (m)
Harbour wt
3.4E-05
6.2E-05
1.3E-04
7.4E-05
4.3E-05
5.7E-05
1.8E-04
2.5E-04
3.2E-04
2.9E-04
2.3E-04
8.9E-05
3.5E-04
5.7E-04
4.8E-04
3.6E-04
4.8E-04
1.1E-03
5.6E-04
2.1E-04
4.2E-04
9.6E-04
1.3E-03
8.2E-04
3.1E-04
5.0E-04
8.0E-04
7.4E-04
2.2E-04
3.9E-05
7.8E-05
1.9E-04
2.1E-04
1.5E-04

Fig 2



FVM Chlorine Plant
Individual Risk: LD50
0.0E+00
4.1E-08
7.2E-08
4.9E-08
0.0E+00
1.7E-07
5.8E-08
6.4E-07
1.0E-06
1.9E-06
1.2E-07
2.4E-06
5.0E-07
1.5E-07
0.0E+00
1.5E-07
0.0E+00
(Thousands)
X-distance (m)

Fig 3

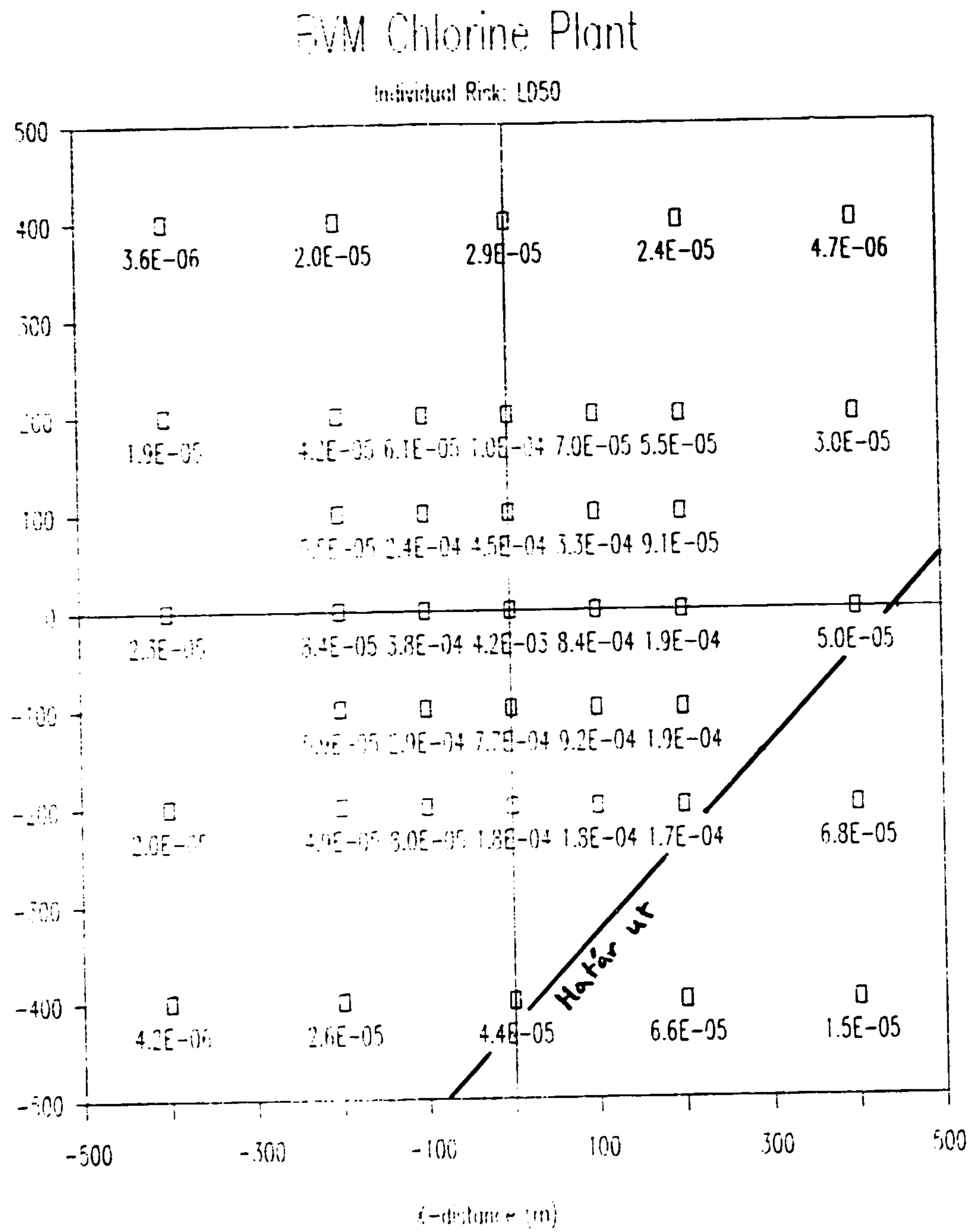

Chlorine Plant
Individual Risk: LD50
3.6E-06
2.0E-05
2.4E-05
4.7E-06
7.0E-05
5.5E-05
3.0E-05
2.4E-04
3.3E-04
9.1E-05
3.8E-04
8.4E-04
1.9E-04
5.0E-05
9.2E-04
1.9E-04
1.8E-04
1.7E-04
6.8E-05
2.6E-05
6.6E-05
1.5E-05
Határ ut
500
400
100
0
-400
-500
-500
-300
-100
100
300
500

Fig 4

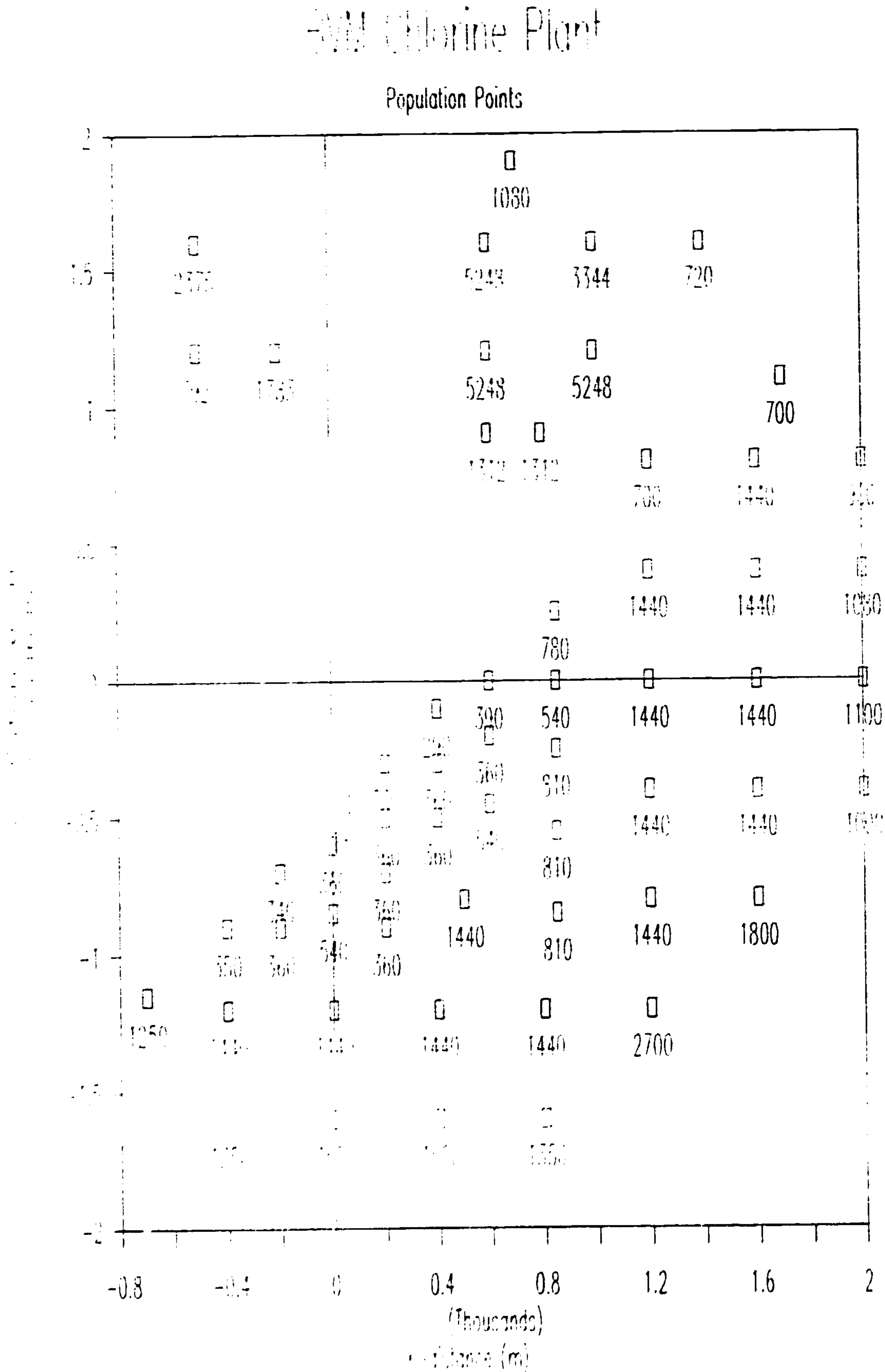

Population Points
1080
3344
720
5248
5248
5248
700
780
1440
1440
540
1440
1440
1100
1440
1440
1800
810
1440
1440
1440
2700
-0.8
0
0.4
0.8
1.2
1.6
2
(Thousands)

Fig 5

BVM Chlorine Plant

Individual Risk: Dangerous Dose

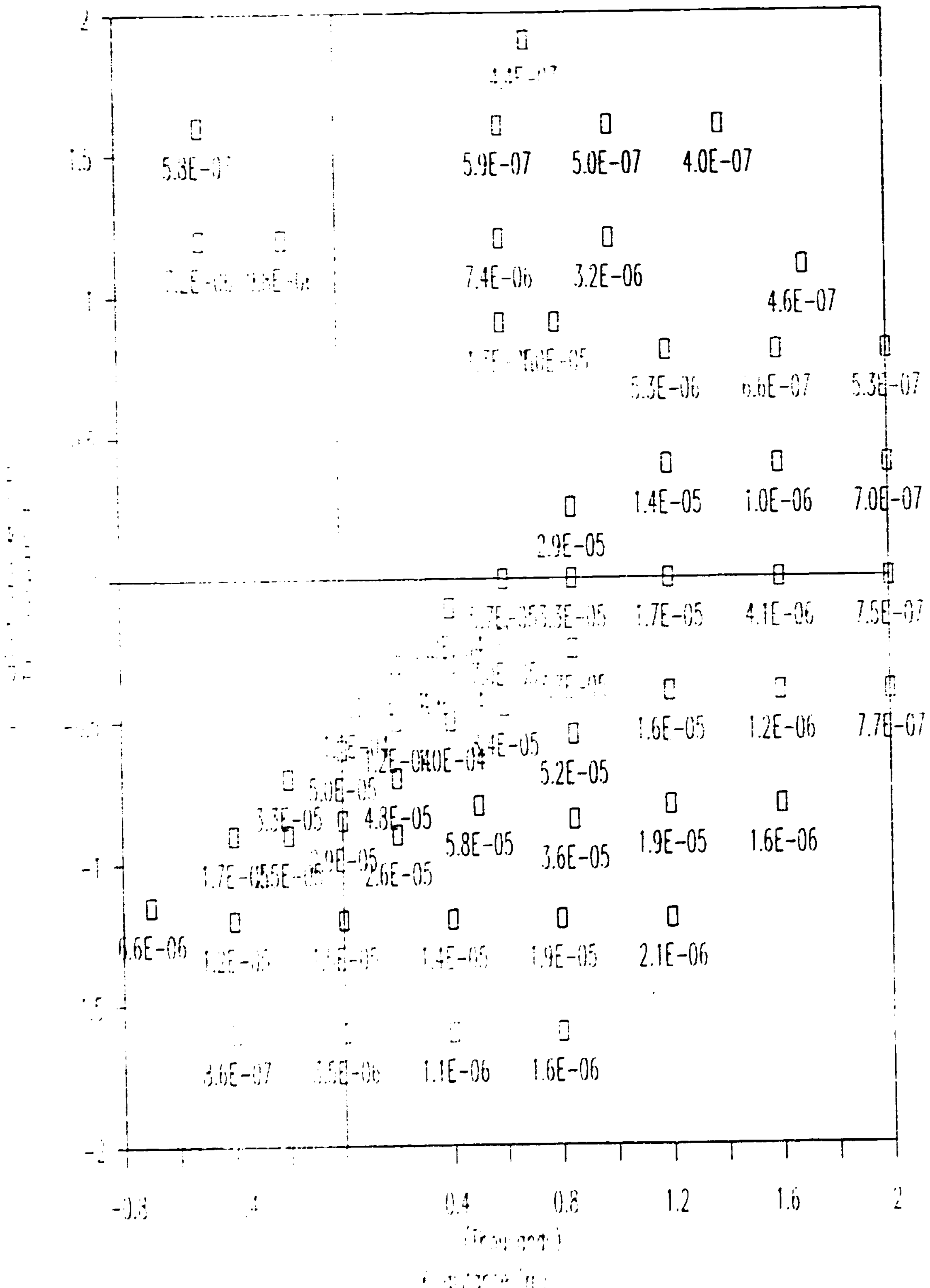


Fig 6

...ine Plant

Individual Risk: LD50

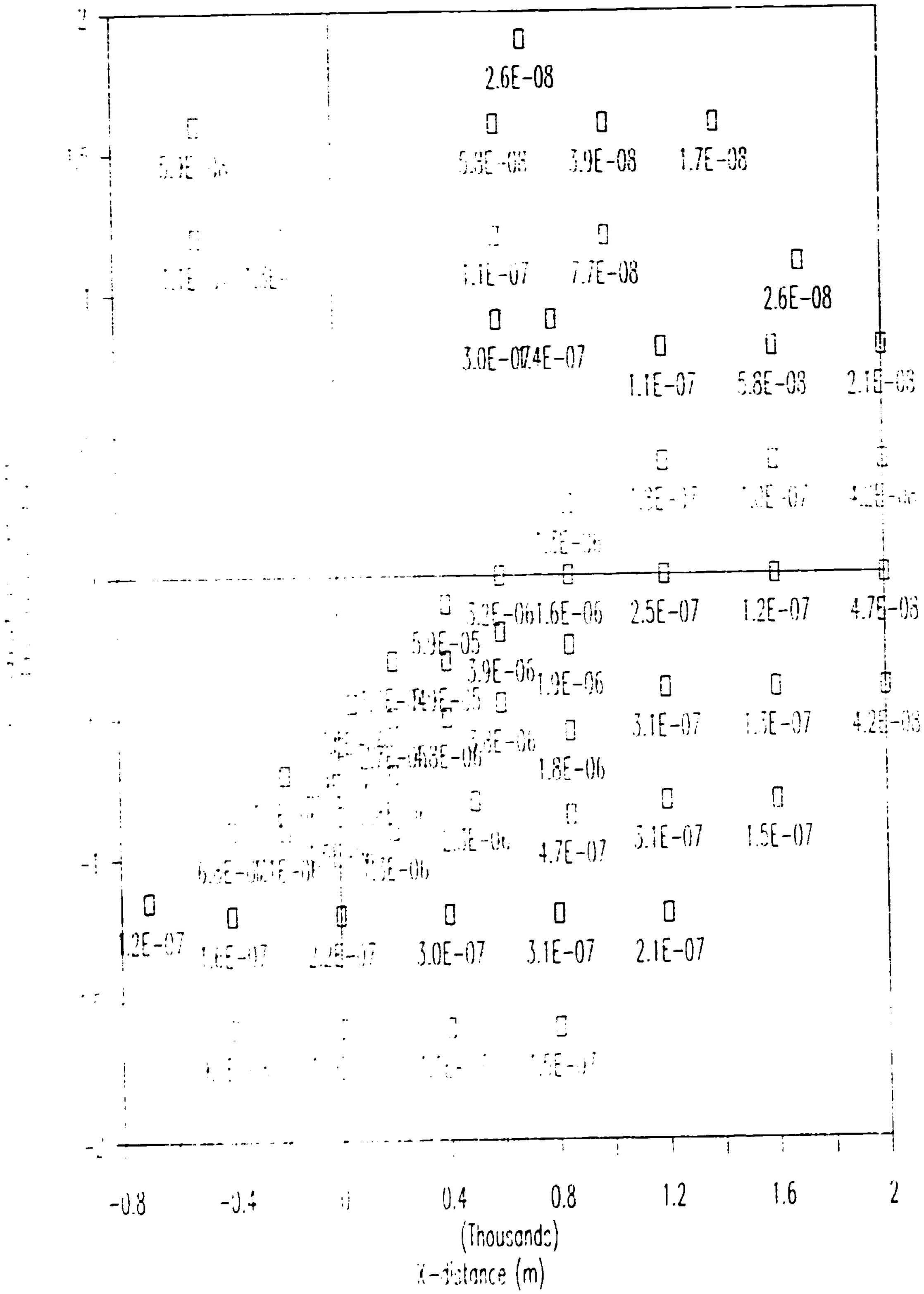


Fig 7

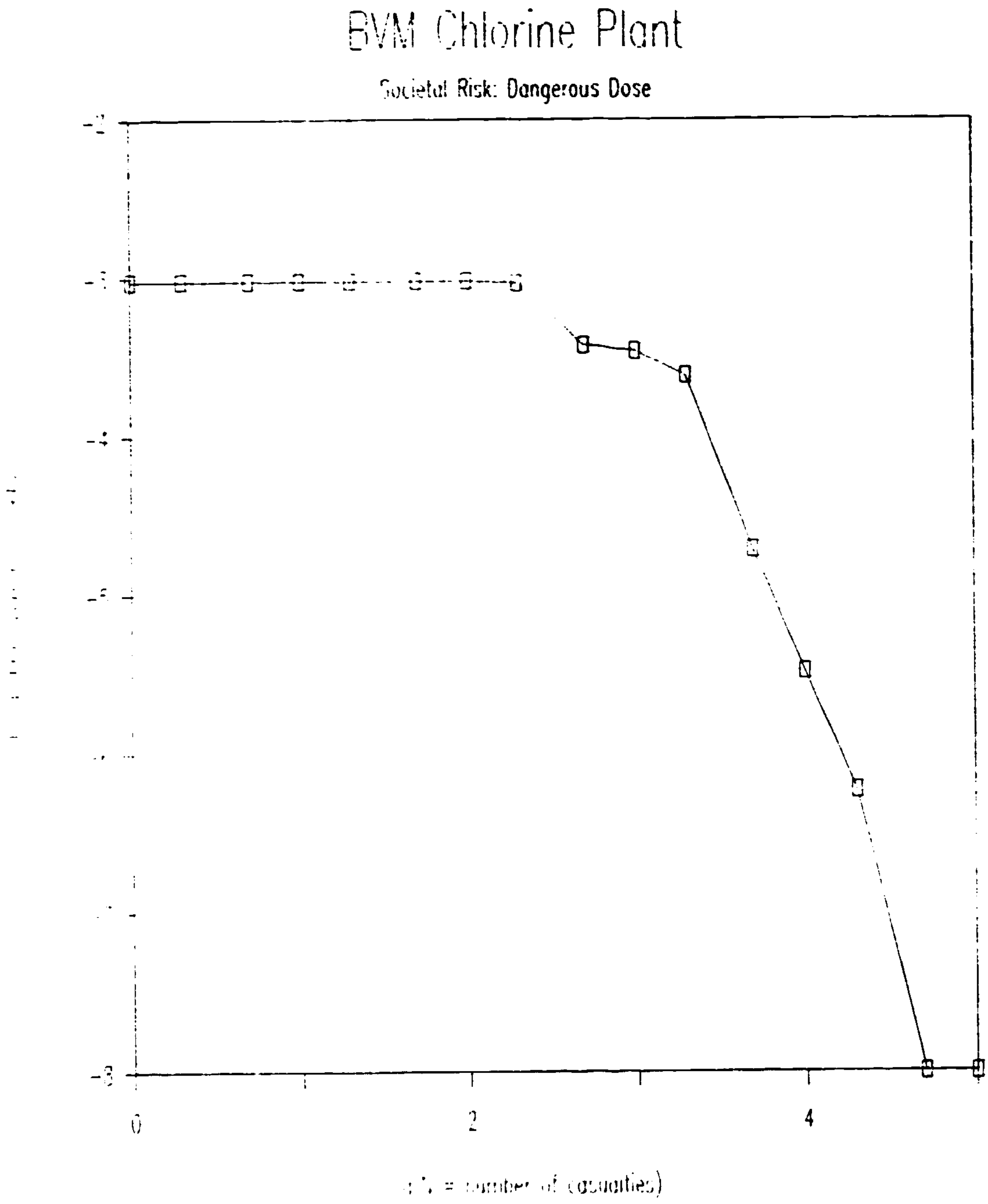


Fig 8

?VM Chlorine Plant

Societal Risk: LD50

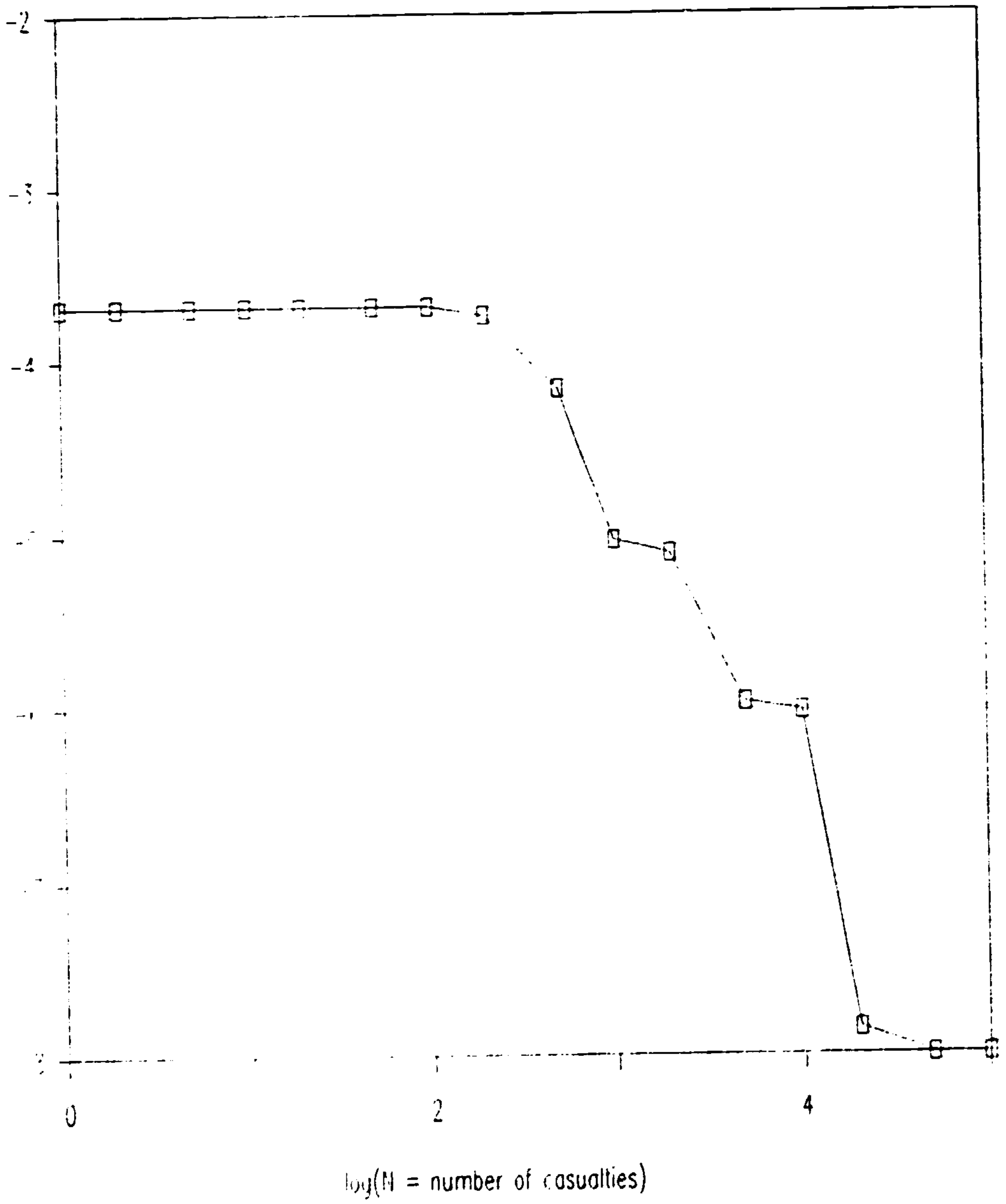


Fig 9