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Distribution
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ID/WG.221/10
15 December 1975

Original: ENGLISH

United Nations Industrial Development Organization

UNIDO/FAI Interregional Meeting on Safety in the Design and Operation of Ammonia Plants

New Delhi, India
20 - 24 January 1975

SAFETY AUDITS IN AMMONIA PLANT DESIGN[1/]

by

E. W. Owen*
and
P. N. Sales**

* Manager of Engineering Development, Humphreys and Glasgow Limited, London, U.K.

** Manager of Process Engineering, Humphreys and Glasgow Limited, London, U.K.

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SAFETY AUDITS IN AMMONIA PLANT DESIGN[1/]

SUMMARY

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E. W. Owen*
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P. M. Sales**

The paper presents a design contractor's viewpoint of the safety aspects of an ammonia plant. Starting from the basic choice of process, the various decisions made in the long path to a successful plant start-up are demonstrated.

The chemical, metallurgical, and other technical problems are discussed in relation to the various sections of the plant, including a discussion on how review techniques may be applied to minimise subsequent hazards.

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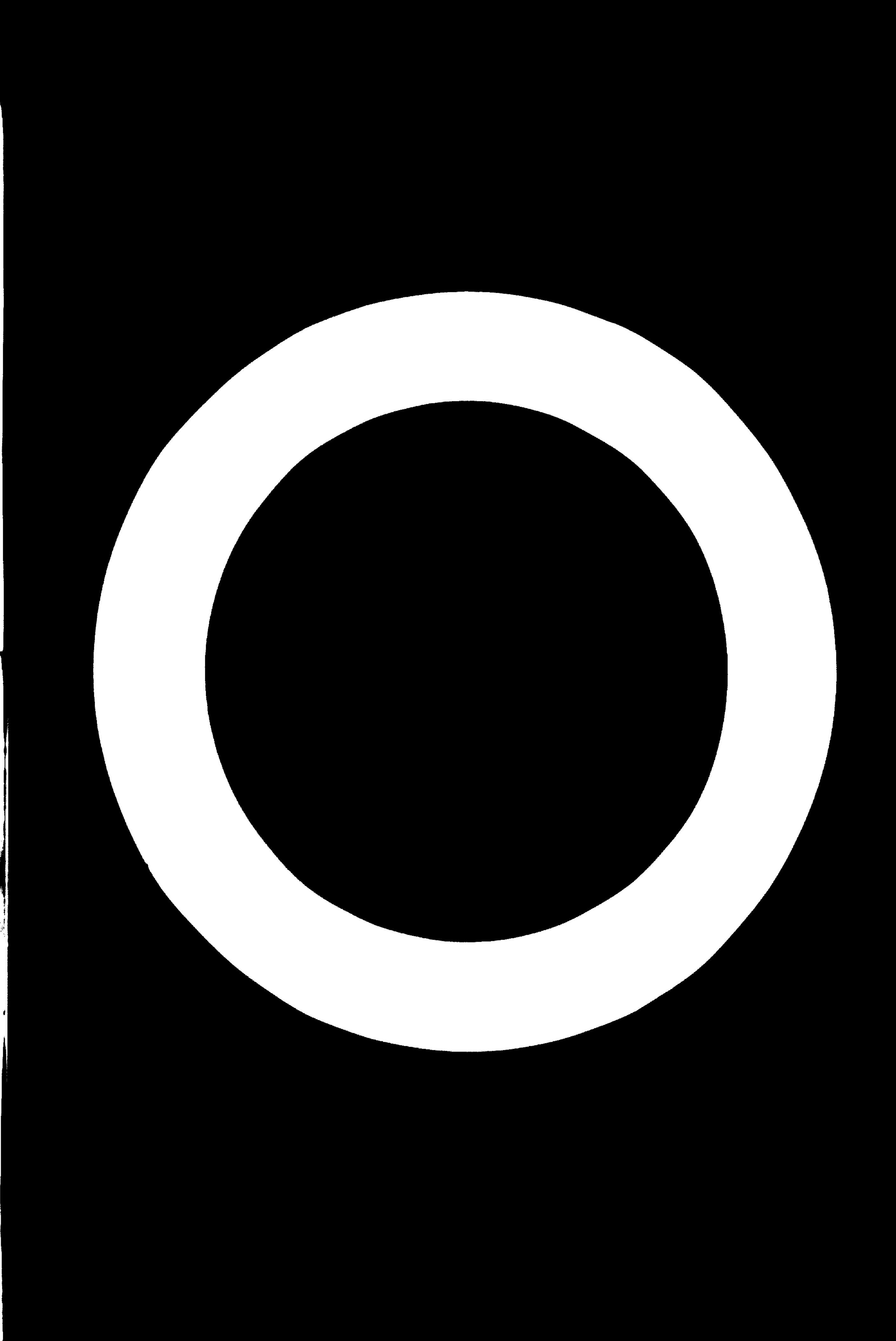

Design [illegible] problems outlined, [illegible] associated with [illegible] and all the other [illegible] overall safety of [illegible].

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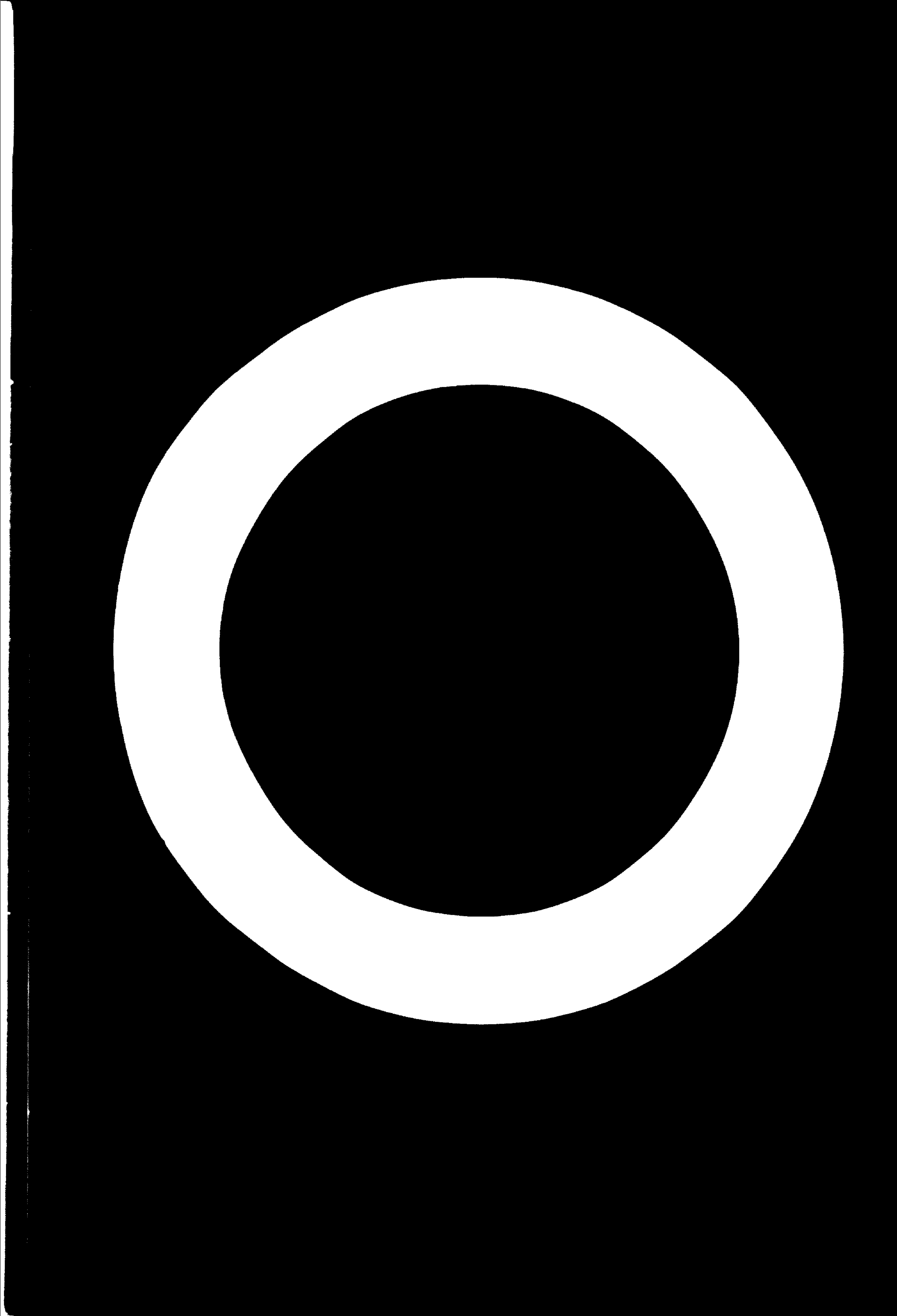

SAFETY AUDITS IN AMMONIA PLANT DESIGN

CONTENTS

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SAFETY AUDITS IN AMMONIA PLANT DESIGN

1. Summary

The last fifteen or so years has seen the evolution of the ammonia production industry to become a significant contributor to world economy. Large units have become relatively commonplace and the recent inflationary situation has led to a considerable increase in capital investment in the industry. This has been associated with a rapid rise in the cost of energy on world markets, and increased concern to protect the environment in which we live. Individual members of the industry have gained considerable experience over these years and as a result, it is natural to consider the auditing of new and existing designs in the light of this experience to ensure all possible safety precautions are taken.

This paper seeks to review key aspects of the design of ammonia plants, how safety is implemented into these designs, and how this implementation may be meaningfully examined or audited.

2. Safety and Reliability

In some areas it may be necessary to distinguish between:

- Safety to Personnel
- Safety to Production, including Reliability.

Where human beings are concerned, whether on the plant, or in the surrounding neighbourhood, every reasonable precaution must be taken to avoid possibilities of accident which may endanger life, limb, or health generally. To protect health, Government action may be necessary to define what is implied by "reasonable", but in general, conditions generated by the plant should be such that the health of no one in the short or long term should be affected by the presence of the plant. This applies in particular to noise, effluent, leakages, etc.

In this paper, no significant distinction is made between safety to Personnel or Production. The emphasis should always be for "Good Design" and a good design should be safe in all respects. Commercial considerations however must inevitably be related to safety to Production and Reliability. Absolute success can never be guaranteed, and to an appreciable extent the saying - "You get what you pay for" - is true. The success of the American Space Programmes is in some measure due to the "Zero Defects" approach - perhaps the most expensive and thorough checking policy ever envisaged to eliminate failure, but the cost of operating such a policy renders it commercially untenable for the Ammonia Industry. Our objective must be for long safe operation between regular routine turn-around periods - a target which can be and has been achieved by a combination of good design and intelligent, careful operation.

3. Basic Principles of Safe Design

Safe design can best be achieved when design principles are developed in response to the following two statements:

- Safety is inseparable from the Design
- Designers and operators, being human, are liable to err.

The design of a modern ammonia plant may require anything between 50 and say 150 man years effort by designers. To produce a satisfactory product, it is therefore vital for the designer to have clear principles by which this large number of manhours may be controlled effectively. It is suggested that the following are three key areas worth developing:

3.1 Good Design Methods

It is surprising how easy it is for a designer left to his own devices to muddle along doing scruffy calculations, making little effort to retain them for subsequent reference. Good housekeeping of calculations is a vital part of safe design and should be encouraged as an essential discipline. Regular supervision should as a matter of routine be carried out by senior engineers. It is often possible to arrange the work of engineers so that each provides an independent check on the other. Consistency with previous designs of a similar size and type is often easy to check and well worth doing.

3.1 Good Design Methods - continued

In a large design office, considerable quantities of information exist and there is no chance whatsoever of one person reading it all or knowing it all. It is very helpful therefore to categorise and segregate information so that it may be easily distributed to those who need it. This information should be linked to a retrieval system giving the designer every opportunity to make best use of what is available. Time is always required to keep this information up to date.

3.2 Communications

However good the methods incorporated under 3.1, it is still necessary to ensure that communication of information between engineers is clear and adequate. Mistakes commonly arise where one engineer assumes another is responsible, the task being ultimately neglected because the second man assumed the first was to do it. What is common sense to one man is not necessarily so to another and a useful maxim might be "Don't Assume". Because design staff are not necessarily permanent, technical instructions need to be locked into a retrieval system as a safeguard against employment of less experienced staff at a later date. The "expert" in anything can be a liability if his expertise is only in his memory. Accidents or ill-health can happen to him and it is inefficient when such information is not available simply because the expert was never constrained to commit his experience to print.

3.3 Best Use of [illegible]

In many [illegible] men are [illegible] away from the [illegible] is most [illegible]. However [illegible] described in 3.1 and 3.[illegible] of experience in an [illegible] way to [illegible] design concept. In [illegible] often necessary [illegible] in a contractors' organisation where [illegible] relatively high throughput of [illegible]

4. Specific Design Attitudes

There is no short cut to safe design [illegible] is needed, particularly in these days [illegible] design has passed and the work of the [illegible] routine, with increased focus on [illegible] is more than ever advisable to behave logically and [illegible] as the following notes imply.

4.1 Aids to Clear Thinking

"After thoughts are often unsafe" is perhaps an overstatement but there are undoubtedly examples where this has been true. The addition of a valve after relief valve philosophy has been completed, a change of process conditions on site without reference to the design conditions, steaming of lines where the steam temperature was not a design parameter. Clear comprehensive thinking at the design stage, with a good understanding of likely site conditions is to be encouraged. An understanding of management techniques of programming, value engineering (ref. 1,2), decision trees, can be a real help. The use of

4.1 Aids to Clear Thinking - continued

diagrams or models can provide co-ordination and avert misunderstandings. The use of check lists can provide a helpful thread through the maze of jobs and calculations to be completed.

4.2 Design for All Conditions

It has been said that it is easy to design a plant to operate continuously, but much harder to design a plant which can be started up and shut down safely, just as aircraft are more accident prone on take off or landing. Steam systems, catalytic reactors, and other sensitive items all need special consideration to ensure unsafe conditions are avoided at all times. There is often a need to project information forward in time, via the Operating Manual or otherwise, from the designer to those who will never meet him but need to know his thoughts.

4.3 Detailed Design by "Others"

Whoever the main designer may be, whether contractor or a member of the operating company's staff, there are always areas such as compressors which are designed largely as packages by "Others". Integration of such packages into the main design concept is an activity requiring patience and perception, since in many cases the style of communication and presentation by the other party is different from that with which the main designer is most familiar. In this area, experience suggests that the use of diagrams to portray the extent of responsibilities can be most helpful, especially if these are developed before final orders are placed. There is a temptation to begrudge

4.3 Detailed Design by "Others" - continued

time spent at an early stage to determine details of the terminations and cross connections which may occur. It is difficult to decide how far the main designer should check in depth the designs of the other party; additional checking is expensive but can be very necessary in some instances.

4.4 Working with Contractors

Although some producing companies use their own design capabilities, many others do not and have to make use of contractors for modifications or new work. It is clearly advisable for both parties to make an early assessment of each others capabilities and to ensure that contracts allow appropriate flexibility to enable the partnership to produce the most profitable result for both parties.

4.5 Use of previous experience

Analysis of problems encountered in your own company or more particularly analysis of other peoples problems is a very necessary part of the maintenance of safe design. This is dealt with in further detail in paragraph 12, concerning commissioning feedback. Much good useful literature is published, which needs to be read and carefully absorbed into design attitudes. Reading proceedings of meetings such as these from previous years can serve as a useful refresher. (e.g. Ref.3).

4.6 Man Management

It seems worth repeating a few basic thoughts:-

"Most technical men have something to say worth listening to". The problem is sorting out what is worth listening to from what is not.

"Learning by Mistakes is part of gaining experience" Much of modern ammonia design practice has emerged from earlier inadequacies. It needs a conscious effort to remember what these indadequacies were. They often get forgotten and the old mistakes become repeated several years later.

"Beware of being told what you want to hear". Learn to enquire further when told everything has been checked and is satisfactory.

"Beware of the pride of the designer". People do not generally like admitting that they are wrong.

"Instructions are often retained in Head Office". Operating Manuals and other detailed information must reach the required working level, just as World Population. Control and Famine Relief Programmes need to result in practical application by actual men and women.

5. Review Technique

5.1 Safety Audit in General

Although some differences in terminology exist, the concept of Auditing Safety is becoming increasingly common. To quote a recent British publication (ref. 4). "The word audit has traditionally been associated with financial accounting procedures, but in recent years it has come into common usage, particularly in the United States of America, in the industrial safety field. In this context it means a systematic critical examination of an industrial operation in its entirety to identify potential hazards and levels of risk". This same publication is a good example of a general framework on which a Safety Audit might be based. It is not specific to any particular process but is based on experience from a number of large safety-conscious operators. Other professional bodies produce more detailed guides on safety relating to specific operations. These guides can provide helpful material for compiling detailed questionnaires (ex. ref. 5).

5.2 Safety Review Techniques in Design

Because of the extent and complexity of Design, review techniques should always be incorporated to minimise the possibility of mistakes and consequent lack of safety. It is recommended that each Company, as a matter of important policy, determines formally who is best able to conduct these reviews; who is to be responsible; when and how are the reviews to be carried out. This policy shou be closely related to the overall design approaches used

5.2 Safety Review Techniques in Design - continued

(see also paragraph 3 above). The purpose of these reviews should be to ensure that the design team have identified all hazards and that their design provides an adequate solution making full use of past experience. It is particularly helpful to screen key information such as P & I diagrams (or ELD's) at meetings attended by the various specialists who have made contributions to these documents. Check lists can provide a useful control on this work.

In Britain the recent Health and Safety at Work Act etc. 1974 has emphasised the responsibility of designers to society in general. As a result Professional bodies in general have been considering how engineers may meet their newly defined responsibility, and at least one organisation has issued a paper advising clear procedures to cover:

a) Routine Design Activities
b) Safety/Operability Reviews
c) Operating Manuals

These sections cover matters such as:-

a) Review of heat and mass balance. How competent is a licensor? Are all extremes of temperature and pressure fully noted? How are toxic fluids to be handled? What are fire fighting provisions?

b) A systematic review of the operability in detail, involving experienced commissioning and operating personnel to examine critically what is intended. One major U.K. Operating Company spends many

5.2 Safety Review Techniques in Design - continued

b) continued

hundreds of hours on this task, reviewing item by item what the effects of changes may be, such as loss of power, rising temperature etc. (ref. 6).

c) Are clear statements on all limitations given? What emergency actions may be necessary?

5.3 Independent Safety Audits in Design

There is an understandable attraction to the idea that Independent Safety Audits must be a good thing. In so far as Design activities are concerned, it should be remembered that the knowledge that an external safety audit is to occur and may induce a feeling of lessened responsibility with regard to safety in the engineers and technicians carrying out the design.

In any event, the principle that "Safety is inseparable from Design" must not be undermined. The competence and experience record of the designers must be weighed against the experience record and likely ability of an Independent Auditor to contribute at the Design Stage. Independent Safety Auditing is no substitute for good design by a team of experienced designers who are encouraged to examine critically each others work. On an existing plant, however, there is perhaps a more clear advantage in the use of Independent Audits, though the same factors apply, namely that safety must never come to be seen as the responsibility of "others"

6. Environmental Aspects

Apart from economic factors, the siting of a plant must take into account various environmental limitations, which may often be under Government Control.

6.1 Hazards

Whilst compared with many other Chemical Operations, ammonia production is not particularly hazardous, certain hazards can occur, which should be anticipated by good design. Ammonia in limited quantities does not rate as a very toxic material. Rupture of a 20,000 tonne refrigerated storage tank would, however, constitute a major disaster and design of such storage should be very carefully considered. A very recent code (ref. 7) advocates the use of concrete bunded tanks, preferably sited well away from residential areas. In these days of violence, sabotage can never be ruled out and storage systems are always attractive targets.

6.2 Effluents

Gaseous effluents should preferably be flared, purging of flare systems being an advisable though expensive precaution against explosion. Liquid effluents in many ways can be more troublesome and likely quantities and analyses should be determined and considered early in the design.

6.3 Noise

Ammonia plants do not make ideal neighbours and in Britain current legislation against noise nuisance leads to plant siting preferably at least one kilometre from the

6.3 Noise - continued

nearest housing area, even after extensive provision on the plant of noise reduction features.

Reliability Techniques

Industries such as nuclear power generation which are extremely capital intensive and use very sophisticated techniques, have been forced to develop and practice reliability engineering techniques to ensure safety in operation. These techniques are well described in the literature (ref. 6) and use mathematics to predict overall plant reliability from measurements of actual reliability of individual plant components. Use of these techniques is clearly to be encouraged in the Ammonia industry, though progress so far seems very limited. Recording and publication of actual reliability data is the greatest obstacle, and the initiative rests at present largely with operating companies. A pragmatic approach to reliability seems to be the norm at present.

Plant Layout including Communications

Plant layout is best developed by a team of people who have a clear understanding and experience in both process requirements and engineering details, including piping arrangement and maintenance needs. Hazardous areas should be carefully considered with as much forethought as possible to the positioning of atmospheric vents and blow-offs. The position of control rooms is inevitably a partial compromise since the cost of cabling etc., dictates that the control room should be as near to the plant as possible, whilst safety requirements suggest that it should not be exposed to hazards which may arise on the plant itself. Whether to install windows or not has recently been a question which has taxed designers. From a safety point of view, the design must always include adequate escape routes to permit operator movement should a fire or other hazard occur.

8. Plant Layout Including Communications - continued

Drainage is often overlooked when preliminary plant design occurs, and every effort should be made to develop a comprehensive plan with the same interest that basic heat and mass balances are developed.

The maintenance facilities which are in reality likely to be available are not always correctly predicted by clients to contractors, and frequently difficulties occur subsequently on site when cranes of the sophistication expected by the design are not available.

Communication needs to be considered as a part of safety when plant layout is developed. A variety of systems exist extending from shouting at one another to the use of pocket radio equipment. On matters such as these, the advice of experienced operating staff can be invaluable. Fire alarm systems should be considered as an essential part of communications

9. Process Aspects

Perhaps the largest contribution to safety can be made if correct decisions are taken at the stage of process selection and development. In ammonia production, choice of feedstock is the major decision and aspects associated with the use of various feedstocks are discussed below.

Irrespective of feedstock, however, it is the task of the process designer to select operating parameters which large fix the task of the other engineers. Choice of basic pressure and temperature levels is important and needs to be related to the philosophy to be used for relief valves. Much of this choice is in the hands of the process licensor, and in so far as safety is

9. Process Aspects - continued

concurned,the individual plant designer is left with the task of determining what to do with the effluents discharged from the process either by relief valves or other start up vents and drains. This area is not particularly well covered at present by codes,and concepts must therefore be developed to suit each particular design. It is often in these very areas that hazards can be overlooked because for example, discharges from relief valves are expected rarely to happen. We have found it increasingly valuable to try to produce as part of the design approach, clear statements of policy with regard to such discharges and relief protection to ensure that a consistent approach is taken by all engineers on the design team.

9.1 Gas and Naphtha Feedstock

These plants are perhaps the easiest to design since they require the least equipment. Appreciable capital is invested in catalysts, and thought is necessary to ensure adequate protection systems are installed.

9.2 Fuel Oil Feedstock

In common with coal gasification plants, oxygen plants are usually required and these need to be treated with respect despite the considerable advances in safe technology over the past years. It is helpful to apply good refinery practice to fired heater design if excessive coking is to be avoided. This is usually achieved by limiting heat trasfer rates and providing proper facilities for periodic decoking. The most hazardous area is probably the gasification vessel itself,and great care is

9.2 Fuel Oil Feedstock - continued

needed to ensure adequate trip systems are specified, properly implemented and regularly tested. As with some coal processes, it is necessary to appreciate that the quantity of reagents contained in the system is very small and as a result it is possible to produce extremely high temperatures very readily.

9.3 Coal Feedstock

Certain pitfalls await the designer who is only experienced in the use of clean light feedstock, such as natural gas. Coal does not flow predictably and designs should anticipate the possibility of blockage and include facilities for freeing them. Byproducts are particularly troublesome, and tar produced is often appreciably worse than that commonly experienced in the oil industry, and can readily turn solid. The hazards associated with leakage are also very high. Approximately 40% carbon monoxide may be present and make gas stream leakage can thus be lethal. Cyanides are also present and these need to be handled with extreme caution, remembering that HCN is more toxic than H_2S and much less readily discernible by its smell. Liquid effluents include phenols and cyanides. Ammonium carbonate can occur in the make gas stream and provisions for clearing blockages must be considered. The problems with the gasifier depend to some extent on the process selected. The possibilities of explosions occur with poor distribution due to bed agglomeration and stirring is often advisable.

9.3 Coal Feedstock - continued

Although ash is not required, the designer must not forget its importance. In some processes if it does not flow, trouble occurs, in other processes trouble does occur if it flows. An understanding of likely properties is most important. Perhaps the most unpredictable feature with coal is the way in which its analysis can vary unexpectedly. Sulphur content, for example, can vary significantly in a single delivery and the flowsheet needs to take careful account of all possible extremes. H_2S content, for example, can vary widely presenting a flowsheet and control problem on the sulphur removal system. Coal can be displaced downstream of the gasifier and provisions are required to minimise the risk of this occurring.

9.4 Control Problems

The control of steam systems in particular on plants using largely steam drives needs careful analysis. Modern techniques render simulation possible, and staff with skill in modern control theory should be used to verify the ability of the system to cope with all possible upsets.

9.5 Abnormal Conditions

The process designer is often the key man to determine the possibility of abnormal conditions. Is there a possibility of vacuum occurring due to vessel steam out? Can anything be done to avoid brittle fracture due to cooling of an ammonia leak? Is the dissolved solid content of the seal water to the CO_2 removal system pumps likely to cause trouble?

10. Engineering Aspects

Many aspects of engineering are covered in depth by various National codes, for items such as boilers, piping, vessels etc. It is not intended to discuss these, although much of the safety achieved by the Ammonia industry is due to these codes. It may be helpful to consider a number of other aspects under the various disciplines involved.

10.1 Civil Engineering

Accurate soil surveys are necessary to ensure success, don't guess, particularly where large machines foundations are involved. Where differential settlement is possible, piling may be necessary to avoid pipework fractures. It is wise to consider carefully where fireproofing of structures is advisable to avoid major collapse in the event of fire. Reasonably good data for earthquake, wind and rain are always necessary.

10.2 Electrical Engineering

On ammonia plants corrosion may occur if joints are not properly shrouded. The normal requirements for earthing etc., must be observed. Equipment must be in accordance with the hazards to which it may be subjected. In the U.K. a particularly helpful summary for chemical plant generally has recently been published (ref.9).

10.3 Instrumentation

Atmospheric corrosion can be a problem unless materials are carefully controlled, suppliers may be unaware of conditions prevailing [illegible] plant. Trip systems are commonly used to avert unsafe conditions - these systems need to be of good proven quality to avoid spurious trips and the risk of damage they bring.

10.4 Heat Exchangers

These items often include large joints which may be subject to damage during precommissioning cleaning unless special precautions are taken. Design should include check calculations to minimise risk of tube vibration during service.

10.5 Machinery

The most important selection the designer has to make is to ensure that the machinery he buys is well proven in service and that the supplier can demonstrate this to be so. If new types of machinery are envisaged, then the designer must be extremely careful to ensure that thorough checking of all aspects does occur, preferably before he places an order.

During the progress of design, checks will be necessary on torsional aspects of the connections between drivers and driven. It is also very necessary to check the ability of various parts of a machine to withstand all adverse conditions, particularly pressure, to which it may be subjected.

10.5 Machinery - continued

Protective devices such as vibration probes will normally be recommended by the supplier but the ultimate choice rests with the main plant designer.

10.6 Fired Heater Design

Burner philosophy needs careful analysis to ensure fuel spillages are not possible due to the absence of suitable interlocks. A variety of flame detection equipment is available. The designer must select carefully the most suitable and reliable for his needs. On auxiliary boilers and other "cool box" areas where auto-ignition of fuel is not certain, full flame failure cut off is advisable on the fuel.

10.7 Piping Engineering

Many manhours are consumed by piping design on an ammonia plant. Individual components are classified by means of a Piping Specification which selects suitable material from the wide range available. Special care is needed to ensure pipe fittings, valves etc. conform strictly to requirements; suppliers especially those operating on a small scale, often have inadequate experience.

Welded connections are strongly preferred; joints can lead to flame impingement damage should leaks ignite. Where two pipes of similar nominal bore but different thickness are to be joined by welding, avoid the pitfall of turning down the thicker wall to match the thinner. A special transition piece is usually necessary in the stronger material (i.e. that used for the thinner

10.7 Piping Engineering [illegible]

w[illegible].

[illegible] is a specialist field which must [illegible] It is necessary to anticipate all possible operating conditions, including steam blowing, etc., to avoid possible overstress. The most likely cause of the major disaster of Flixborough in Britain, was due to a lack of appreciation of behaviour of an expansion bellows under stress.

Specification of field test requirements is generally a design responsibility and requires careful planning to ensure all parts of a system are adequately tested. Design codes usually give most of the guidance necessary.

10.8 Metallurgy

It must be remembered that without metals, the Ammonia industry would not exist and good metallurgy is an essential component of all plant design. Full account must be taken of fluids handled, hydrogen content, temperature, but often more important is the need to understand how to treat materials during fabrication. Hardness testing, ultrasonics, dyechecks are but some of the means the designer must call up when appropriate. Codes give much guidance, but there is no substitute for a trained metallurgist to spot the dangerous defect in a design, whether it be paint on outlet pigtails, a wrong welding specification, or an unsuitable material liable to suffer stress corrosion.

11. Procurement

Purchasing, inspection and delivery of equipment and materials requires management which is safety conscious. The designer must be careful to specify precisely what he requires. In developing countries it is rarely sufficient to specify items to be in accordance with the appropriate code. Unlike in Europe or U.S.A., the purchaser must spell out in detail precisely what the code entails and must apply rigorous inspection to ensure the items supplied conform. Materials of construction need careful control, even on non-process items such as electrical enclosures to ensure they are suitable for the duty and plant atmosphere. Remember the supplier will usually make a bigger profit by selling sub-standard material. It is worth spending money to ensure bulk items such as piping, which can become mixed up in transit, are carefully marked or colour coded to avoid unsafe installation. The use of portable testing devices, such as the Metascop metal spectroscope, can detect rogue materials, and it may be necessary for the design team to call up such testing.

12. Commissioning Feedback

Learning from experience is a very necessary part of design. The commissioning and operation of plant provides a very valuable source of information to the designer, not only to tell him about the mistakes he may have made, but also to provide suggestions for improvement. The commissioning of a plant commonly does not occur until some 2 or more years after the basic design has been completed, by which time the designer had perhaps forgotten the detail of some of the features of his work. It is therefore very advisable that feedback from site be carefully regulated and analysed to provide information in a form most suited to designers. With this in mind, my own company has for the past 10 or more years used a Problem Reporting system to formalise communication between site and the design office. A sample Problem Report is in para. 15. These reports recognise that some measure of corrective engineering may be necessary, and encourage site to state their problems discretely. On receipt in H.O. reference is made to a keyworded problem file to determine if the problem has arisen previously, and using this information or other means, a solution is determined and site advised accordingly. Use of keywords is kept to a minimum and we use about 300 carefully selected words from which we may define a problem. These keywords are used to gain access to our main problem file which currently contains over 900 separate problem cards, each card relating to a specific problem encountered in practice. These problem cards are analysed periodically and from them check lists are produced for use on new designs to minimise the risk of an earlier problem being repeated. (Example in para. 15). The cards are also used to indicate areas where design techniques, purchasing specifications and commissioning procedures need improvement,

12. <u>Commissioning Feedback</u> - continued

these improvements being fed directly into the main company standards system.

Although site personnel are encouraged to propose solutions to the problems they find, it is not uncommon to find that, because they do not have access to all the designers' information, they are attempting to treat symptoms without diagnosing what the true problem is. As an example of this, some years ago a CO_2 absorption system was just failing to reach required performance. Much effort went into querying the design basis. Ultimately the design team became suspicious of the details of the liquor distribution system; it looked as if all the feed would go to one side of the column. As a result, site made some tests and found that only about 1/3 of the column was wetted at the top. Since then we prefer to do water tests as part of commissioning to verify suitability of distributors.

When the system was introduced, plant sizes were small, but tending to increase. We began on site to find control valve difficulties which were traced to a design fault: the maximum differential pressure to which valves were subjected on trip was not being stated and valves were being bought with insufficiently powerful actuators. At a similar time, convection bank performance was low and was traced to air inleakage. This led to our normal practice of leak testing convection banks as part of precommissioning preparation.

13. Conclusions

It is hoped that this paper shows how closely safety is linked to good design and that the first question to ask is always: 'Is the design policy likely to be sound, thoughtful, and carefully carried out?'. The answer to this question will clearly relate to the competence of the engineers doing the work. If these requirements appear to have been met, safety auditing can then be undertaken as a meaningful task. If not however, (remembering this paper refers to the design task), then it is doubtful if the design should be allowed to proceed at all.

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Humphreys and Glasgow, Ltd.
London, S.W.1.

PROBLEM REPORT

Site:

Sheet No. ONE

[illegible] 29/2	**Site Classification:** H.O. Action Requested/~~Information Acquired~~/For H.O. Information
Receipt via:	**Nature of Problem or Incident:** Boiler System Degreasing — Damage to Aluminium Gaskets using 0.4% NaOH Soln
[illegible] No. S1756	
Reason:	
Date 27-6-[illegible]	**Specific Details:** H1252/1253/1257/1402 Boiler Feedwater Exchanger. During caustic wash of boiler system (0.4% NaOH Max 40°C) main head leaks developed. Aluminium gaskets had been subject to attack.
Processed by:	
Date:	
	Site Action Taken: From info available at H.O. (PRS 50's subsequent letters following Vendor's visit to site) it appears that Al gaskets can be reused following machining and are satisfactory
Contract Digits	
Project Manager/	
Project Engineer	
Process Eng./	
Group Head	
	NOTE: Area beyond Double Line for H.O. Use

Formal Statement(s) for Information Retrieval (Keywords underlined)	Retrieval Card Nos	In Cu[illegible] Nos
CORROSION DAMAGE to HEAT EXCHANGER	311	[illegible]
JOINT FAILURE	48	[illegible]

Specialist Eng:	
Site	
Site D-1	
(Temporary)	
	Preliminary Assessment: (Stating Grounds for any further action proposed on this contract, etc.) Discussed with Designers. Above action OK in short term.
Original	
Commissioning/	
TG Head/	
File D-1	**Outline of ACTION on this Contract:** As above. Alternatives open seem to be: 1. Try Copper shims after cleaning 2. Try soft iron sealing
Additional Distn.:	
	General Notes: (Points for further designs etc.) Discussed with Metallurgical [illegible] view. If NaOH less than 0.3 ppm corrosion in normal operation unlikely. PEG: Please investigate current jobs. Caustic soda to be used elsewhere – we must avoid further occurrence.

REVERSE OF THIS ORIGINAL MAY BE USED FOR ANY CONTINUATION NECESSARY

PROBLEM NUMBER	QUESTION	ANSWER	ACTION SHEET NO.	REMARKS
58	Is there a risk of impingement damage to condensate filter [illegible] ?	No [illegible] water [illegible] with weir over-flow. [illegible] partment fitted with drai[illegible].		
59	Is [illegible] on [illegible] storage tanks gas tight ?	[illegible] vented [illegible] oil [illegible] type.		Comm. Eng. to check
61	Has purge point been provided [illegible] of block valve on [illegible] gas stream ?	Not provided - suggest [illegible] adopted.		Comm. Eng. to arrange if necessary.
62	Is there risk of contamin-ation of condensate with gas absorption [illegible] ?	[illegible] Plant - yes, if back flow from CO_2 Absorber to Absorber [illegible] Vessel [illegible] due to mal-operation or serious upset. On Amine Plant, Recycle Knock Out Drum and Absorber Knock Out Drum provided before and after CO_2 Absorber respectively hence risk here minimal. Note conductivity alarm provided by WMCH on soft water sump tank per CN 47.		Care required in operation.
63	Do steam/feedstock trip and alarm operate from separate transmitters ?	Yes, per [illegible].		
66	Is instrument air supply adequate ?	Was original basis for Stream Instrument Air Compressors for supplying that stream plus the common services ? And have too many instruments been added on change notices ?		Instrument check required. Later checked all OK.
67	Is delay fitted to Furnace Box PH 60 ?	Yes, O.K. although not shown on ELD (called up in detail on instrument process data sheet).		Comm. Eng. to check and report any difficulty.

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