OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

2859

Distribution
LIMITED

ID/WG.221/11
20 December 1975

United Nations Industrial Development Organization

Original: ENGLISH

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

New Delhi, India
[illegible] January 1976

A REPORT ON A FIRE IN THE AMMONIA SYNTHESIS UNIT[1/]

by

A.L. Seth*

* Shriram Chemical Industries, Naaz Building, 1, Jhandewalan, New Delhi - 110055 India

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.

id.75-9166

We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards even though the best possible copy was used for preparing the master fiche

06859

Distribution
LIMITED

ID/WG.221/ [illegible]
20 December 197[illegible]

United Nations Industrial Development Organization

Original: ENGLISH

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

New Delhi, India
20 - 24 January 1976

A REPORT ON A FIRE IN THE AMMONIA SYNTHESIS UNIT[1/]

SUMMARY

by

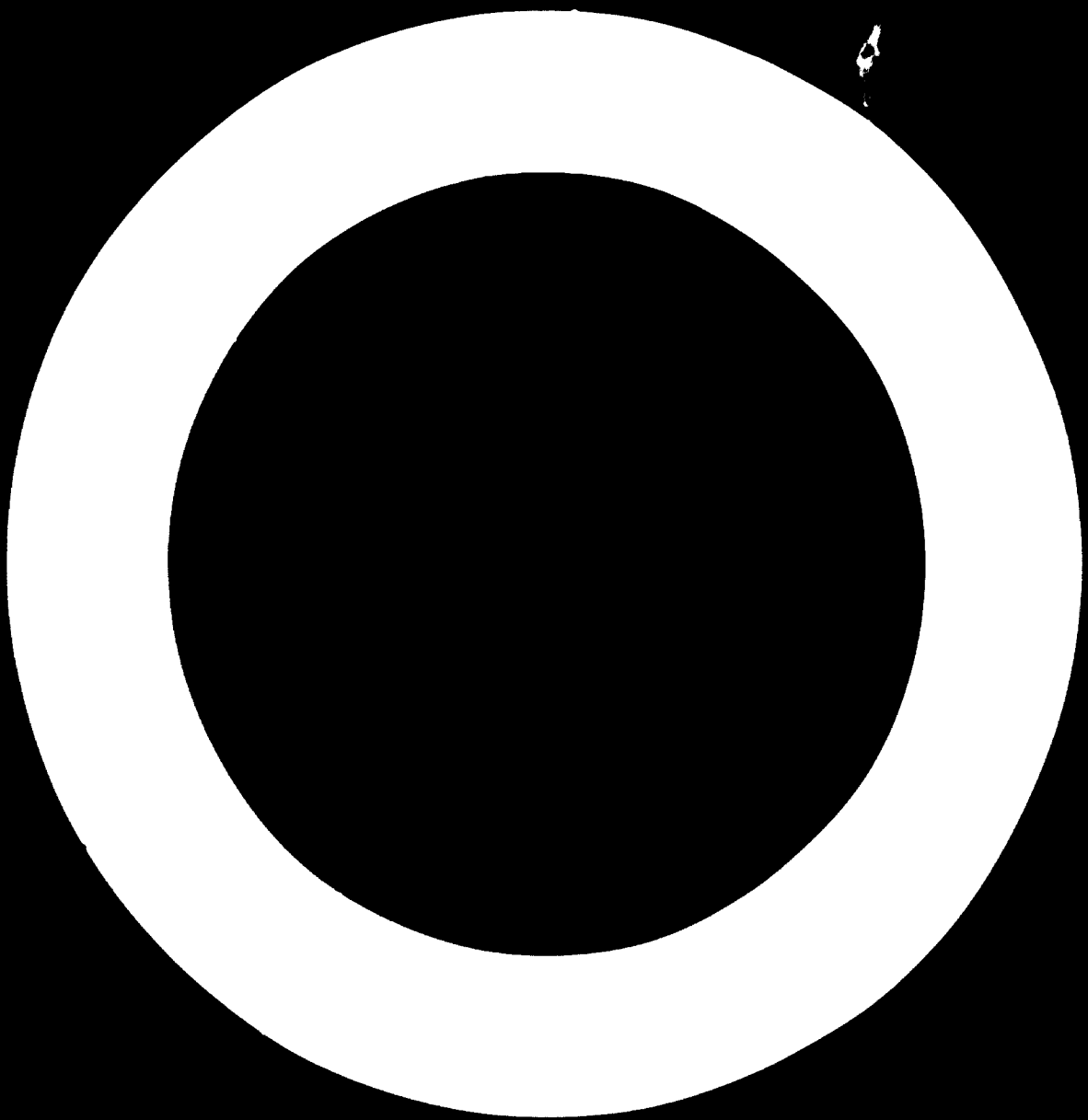
M.L. Seth*

This is a report on the occurance of fire in Ammonia Synthesis section of the 450 tons per day ammonia plant of Shriram Chemical Industries, Kota.

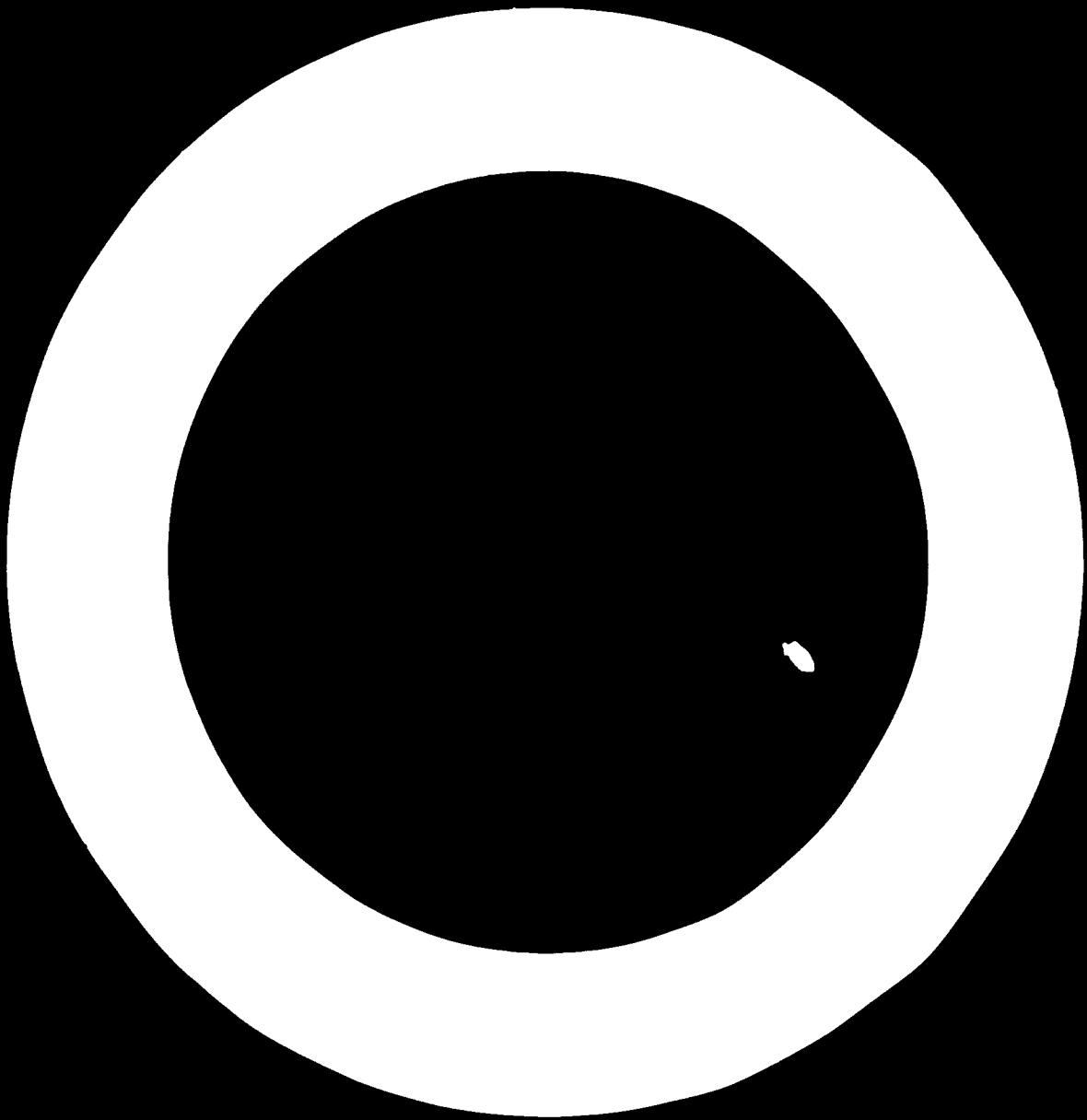
The fire occured during a routine start up of the ammonia synthesis section at the beginning of commissioning of the plant. Whenever there is any explosion and fire it is very difficult to analyse the causes with any accuracy since such a explosion would have destroyed many of the proofs. The most probable causes of the fire are discussed. The modifications carried out to avoid similar incidence are also detailed out.

* Shriram Chemical Industries, Naaz Building, 1, Jhandewalan, New Delhi - 110055 India

1/ The views and opinions expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. This document has been reproduced without formal editing.



The risk of explosion and fire is always present in all ammonia plants. Ammonia plant process highly explosive gases like hydrogen and carbon - monoxide and nitrogen-carbon. Process is at very high temperature and pressure. Under these conditions any explosive mixture with air or oxygen in a confined space gives rise to explosion and fire. These gases under pressure when they leak through a restricted passage catch fire. Armstrong effect may also be the cause. Any catalyst dust or iron rust present will help ignition. The heat generated by friction may also cause ignition. Hydrogen has a property of undergoing heating on throttled expansion and this heat generated can also ignite the gases. Most of these explosions occur while starting or shutting down the plant and extreme care is necessary during these operations. Explosion and fire is always a hazard while carrying out hot work on equipments. Every care should be taken to make certain that particular and adjacent equipment do not contain explosive mixtures.



INTRODUCTION

The Ammonia plant has a capacity of 450 tons per day and is laid out in a single stream. It is based on the steam Reforming of naphtha. The Ammonia Synthesis Section is based on the Topsoe Medium Pressure Synthesis process operating at 310-320 Kg/cm^2g pressure. The plant was commissioned in February 1969 and had operated for over 27 days before the accident.

SEQUENCE OF EVENTS :

The fire occured at 10.45 PM on 2nd March 1969 in the Ammonia Synthesis section. At that time the plant was being restarted after a stoppage for maintenance jobs. The Ammonia Synthesis Section had been pressurised to 250 Kg/cm^2g for a leak test. This was routine job prior to lighting of the start up heater. A small leak was detected at a flange on the check valve on No.2 Oil Separator gas inlet line. The Separator was isolated and was being depressurised. Depressurisation was being done by opening out the vent valve to a 2" vent line which connects to a common 10" vent header. The fire was observed near the Ammonia Separators and Chillers.

The synthesis loop was immediately depressurised. The fire was in the area of the Ammonia Separators and Ammonia Chillers (figure 1). The material used for cold insulation of these equipment was Thermocole (foam polystyrene) with Bitumen coating for weather protection. The fire spread due to burning of the insulation material on these equipment.

DAMAGE CAUSED TO EQUIPMENT :

The major vessels damaged by the fire included :

- No.1 Ammonia Separator
- No.2 Ammonia Separator
- Cold Heat Exchanger

The equipment had been discoloured due to heat. No.2 Ammonia Separator shell showed bulging at six places at there were also 2 cracks on the surface of the shell.

The piping and instruments around these equipment had been distorted or partially burnt by the fire.

The cold insulation on these vessels and on the purge gas chiller and purge gas Heat Exchanger and piping in this area had been burnt.

The vessels were repaired and damaged piping replaced and plant production was resumed within a month of the accident.

A detailed investigation into the cause of the fire was made. In this we were assisted by our plant designers M/s.Chiyoda Chemical Engg. and Construction Co. Japan. The investigations included metallurgical tests and studies on the damaged equipment and piping.

The following important observations were made after the fire :

1. The level control instrument tubing on No.2 Ammonia Separator had broken off at the flange neck.

   The welded part connecting the connection tube of the tee joint and the flange neck of the L.C. tubing was found broken (figure 2) The details are shown in Figure 3.

2. The liquid side of the L.C. tubing on the Ammonia Separator No.2 had burnt at a point 100 mm above the first floor level as shown in figure 4. The burnt was on the side of the 12 B gas line as in figure. The tubing was also burnt around the burnted part indicating that it had been exposed to heat.

3. The main 10" vent Header had shifted along a considerable length. The synthesis section has a common 10" vent Header to which the various vent lines from the equipment were connected (figure 1). These include the vent lines from :

   - No.1 & No.2 Oil Separators
   - Ammonia Chillers A & B
   - Purge gas chiller
   - Waste Heat Boiler

   The 2" Vent line from the No.2 oil separator had snapped

where it joins the 10" vent header.

The inner wall of the Vent Header was found to be dry and free of carbon deposit through a length of about 9 meters in the horizontal section near the No.2 Ammonia Seperator while the inner surface of the remainder of the vent header was found to be wet with oil. Approx. 12 mm depth of oil remained in the horizontal part of the Vent Header between the Ammonia Chillers and the portion referred to above.

4. Both the two rupture discs (6B) on the Ammonia Chillers A & B had burst while the rupture disc on the Purge Gas Chiller had remained intact. The design bursting pressure of the discs was 20.6 Kg/cm^2g.

5. The level gauges on the No.2 Ammonia Seperator were damaged The edge of each of the 2 glasses in the lower level gauge had melted while all the upper level gauges were intact. In both the upper and lower level gauges all the back side 'O' rings and asbestos sheet packets had burnt.

CAUSE OF THE FIRE :

The probable causes of the fire were :

- Break at the level control tubing on No.2 Ammonia Seperator.
- Leakages from the level gauge on the No.2 Ammonia Seperator.
- The sudden release of pressure from the 2" depressurising line of the oil seperator might have developed excessive pressure and the line had snapped from the 10" vent header causing the explosion in the vent header.
- The liquid hammer created in the 10" Header due to the sudden opening of valve and depressuring from the oil seperator.
- Rupture of the bottom line of the No.2 Ammonia Seperator.

A detailed investigation of each of the above probable causes for the fire was made and the conclusions are summarised below : The fire could have been caused by a break that took place in the 1/2" tubing connection of the No.2 Ammonia Seperator when the entire Ammonia Synthesis Loop was undergoing a leak test at the pressure of 150 Kg/cm^2.

A crack opened up at the flange neck of the upper LC tubing; gas leaked out through it and got ignited; eventually the crack opened up completely around the circumference of the neck, letting the LC tubing snap away from the flange neck; and the jets of gas spouting out from the open end of the flange neck and the open end of the freed connection tube continued to burn. As to the source of ignition, some tiny particle of iron powder or scale which existed inside the LC tubing might have been blown out by the gas spouting and generated a small spark from impingement on the surfaces within the tubing or the sharp edges of the crack.

A small spark that might have been generated electrostatically by the gas spouting could also have been the cause of ignition. Tests revealed that the crack in the flange neck of the No.2 Ammonia Separator was caused by an uneven stress distribution that had existed in the body of the metal, consisting of the flange neck and connecting tube that had been welded on to the flange neck.

The damages on No.2 Ammonia Separator's level gauge & No.2 Ammonia Separator's stand pipe assembly were caused by the fire which started at broken flange neck in the L.C. connection piping of No.2 Ammonia Separator.

The puncture in the lower part of the LC connection piping of No.2 Ammonia Separator, was also indirectly, caused by the fire which had started at the flange connection of No.2 Ammonia Separator's level gauge standpipe assembly.

The burst of the rupture discs on the Ammonia Chillers, A&B could have been caused partially by the heat of the fire and partially by the emergency depressurising operation of Ammonia Synthesis Loop which had been conducted after the start of the fire for the purpose of minimizing possible damages.

Sudden release of ammonia after bursting of the rupture disc, could have snapped the 2" vent header from 6" header and also caused vibration and dislocation of the 10" header. After snapping of 10" header and 2" header, the gas released caught fire.

It is also likely that an explosion took place in the Main vent Header and caused the rupture disc to burst.

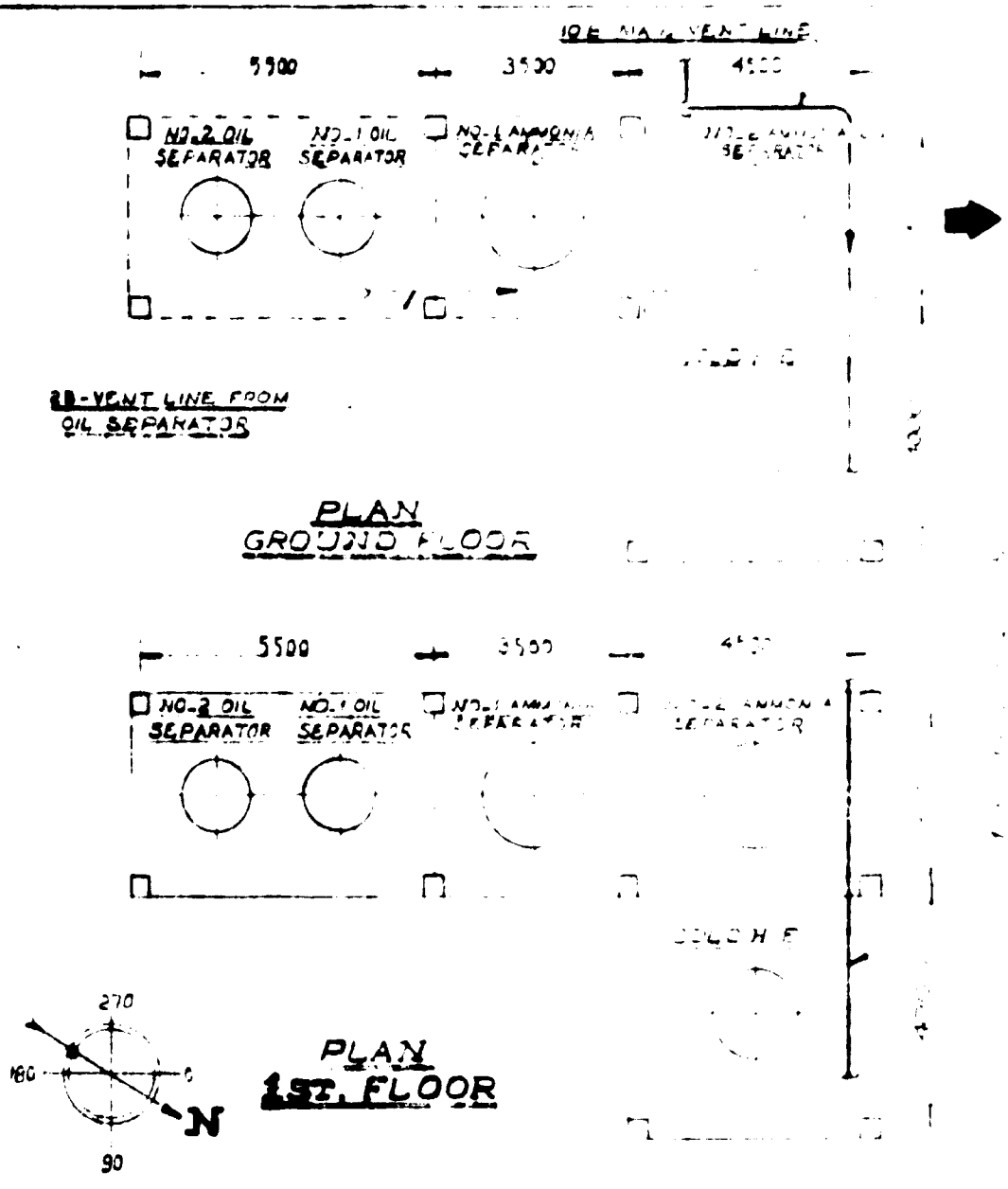
At the time of fire as reported the No.2 Oil Separator was being depressurised and Vent Header was full of synthesis gas. The synthesis gas along with any oil remaining in the Header could have formed an explosive mixture. The source of ignition would have been a small spark of some tiny particle of iron powder.

The oil and water accumulated in the main vent Header was the result of steaming of the oil separator 2 days before the fire. When the synthesis gas from No.2 oil separator was being vented, the oil could have offered sufficient resistance to cause a liquid hammer in the line resulting in its rupture, dislocation and fire.

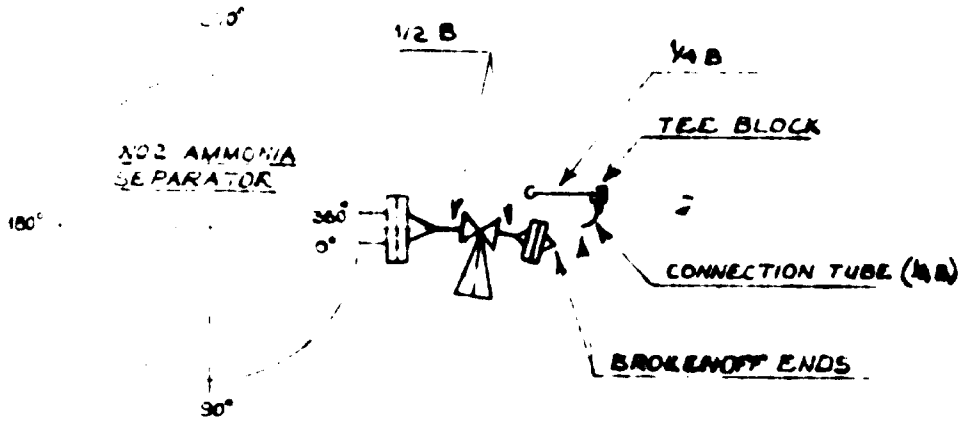
[redacted]:

As a result of the investigation the following modifications were done to avoid similar accidents and these measures have been effective.

1. The Tee connection of the level control tubing was modified.
2. The common vent Header system was removed.
   A separate vent was provided for each of the oil separators.
   A separate vent was provided for the Ammonia Chillers and purge Gas Chiller.
3. The cold insulation material used was Thermocole bonded with a fire resardant resin. Also the insulation was coated with cement instead of Bitumen for weather protection.



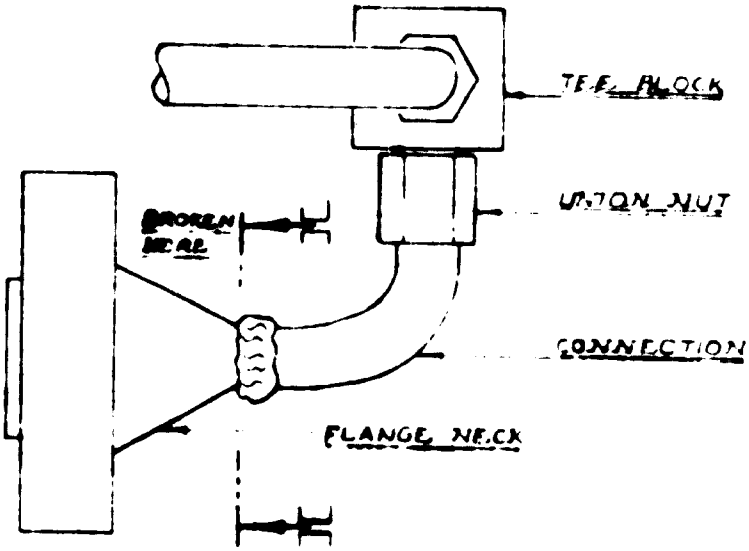
TITLE FIG. NO-1 SYNTHESIS SECTION FLOOR PLAN			
	SCALE		DATE 18 9 75
	TRACED		APPROVED
	DRAWN	[illegible]	
	CHECKED		
PROJECT	JOB	DRG.NO	REVISION



NOTE.

TEE BLOCK CONSISTS OF A TEE BLOCK THREE (3 Nos) CONNECTION TUBES (¼"B) AND THREE UNION NUTS.

TITLE FIG. NO-2 NO: 2 AMMONIA SEPARATOR SHOWING FAILURE IN LEVEL CONTROL TUBING			
	SCALE ——		DATE 15.9.78
	TRACED		APPROVED
	DRAWN	[illegible]	
	CHECKED		
[illegible]		DRG-360	[illegible]

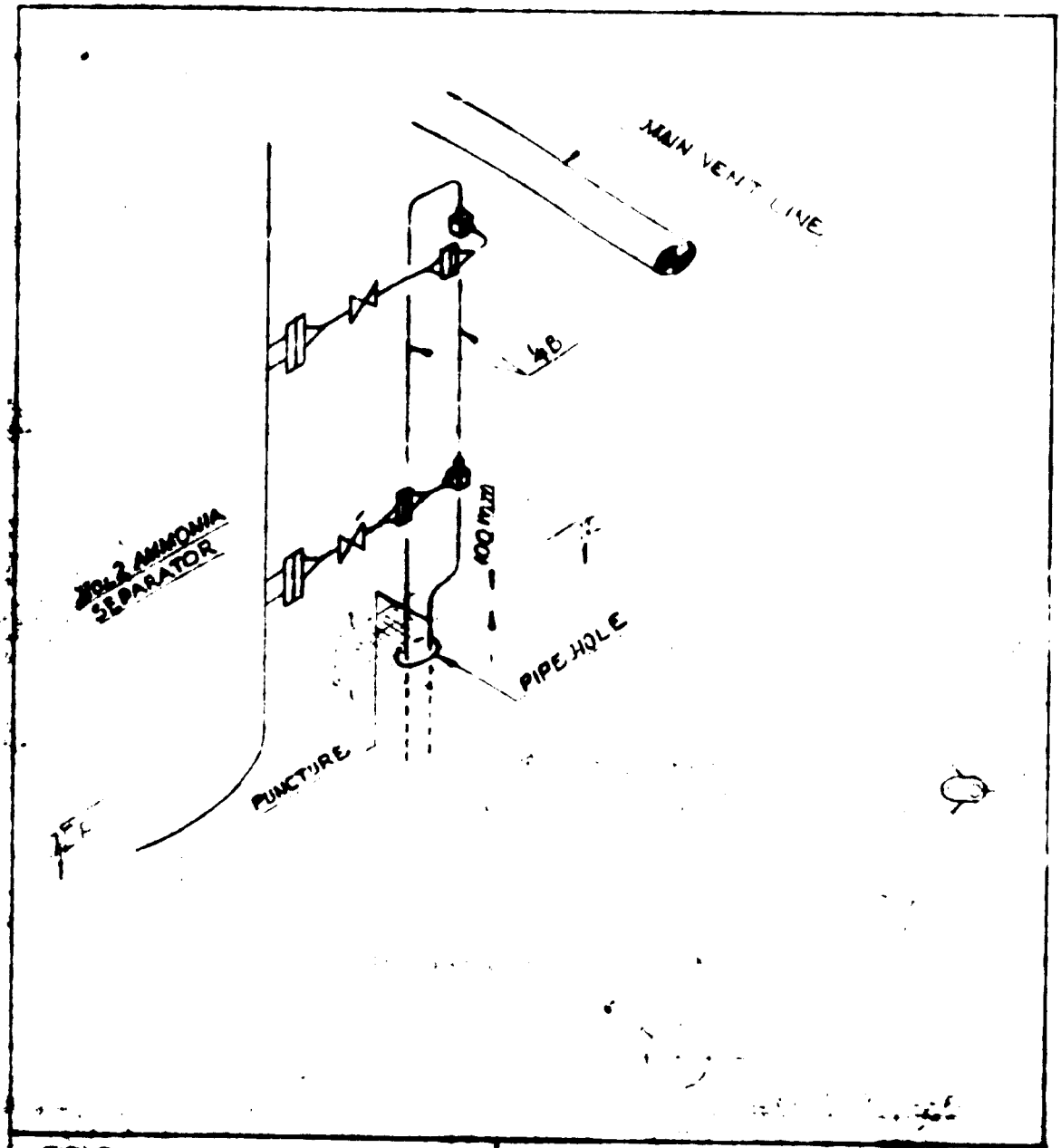


TITLE

FIG. NO. 3

DETAIL OF LEVEL CONTROL TUBING.

SCALE	—	DATE 19.9.75
TRACED		APPROVED
DRAWN		
CHECKED		
DWG. NO.		REVISION



TITLE

FIG. NO-4

...2 AMMONIA SEPARA...
...SHOWING PUNCTURE...
...LEVEL CONTROL...
...NEAR FLOOR

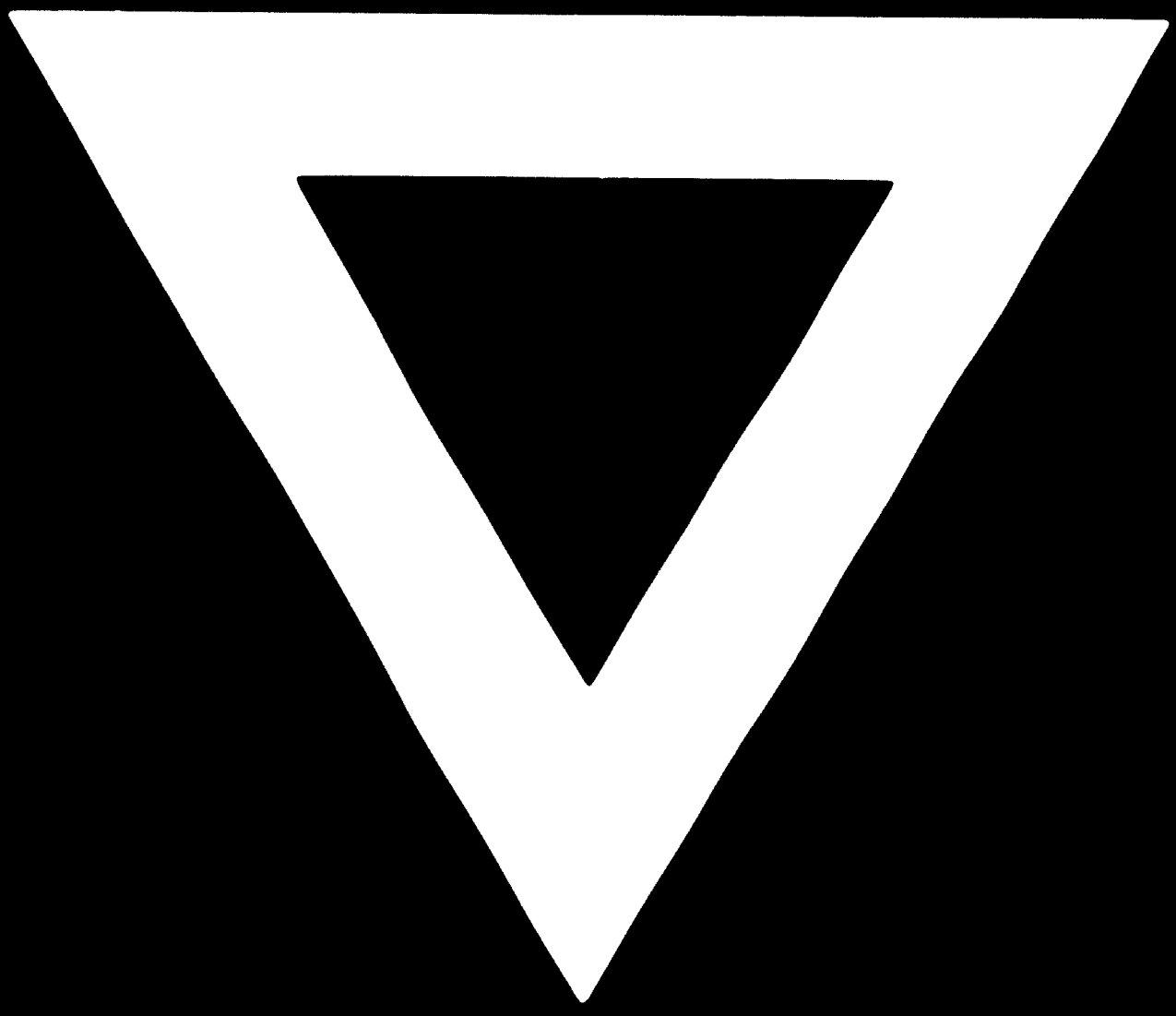
SCALE —— DATE 15.8.75

TRACED

DRAWN

CHECKED

APPROVED



76.07.01