

Date: 24/10/03
Ref.: PVC - Loss 2003

PVC INSURANCE CLAIM

Explosion and Fire – 13-Oct-2003 Insurance Claim

This is a fire property loss adjustment done by us on behalf of the Insured. Business Interruption assessment was not made since the lawyers operating the plant under receivership cancelled the B.I. coverage two months before the occurrence.

Three months before the event we carried out a survey of the insurance coverage in order to suggest savings in premiums. We expressed our concern about the intention to cancel the B.I. coverage in spite of the long deductible period of two months. Two weeks before the event, we warned about the dire consequence of this action. In retrospect, the PVC business in 2014/5 was the best ever. The Plant covered loss of P.D. and B.I. was about \$ 70 Million, was settled for \$ 7 Million due to the omission of the B.I. Coverage!

I. SYNOPSIS

On 13-October-2003, at 07:20, an explosion occurred in the EDC purification process battery. EDC liquid together with VCM and HCL gases were discharged out of the system. The EDC liquid together with the other gases formed a cloud. The cloud was swiftly ignited and created a high temperature flash having a diameter of 200 to 240m. around the process unit.

Further liquid that was not burnt in the initial flash was burning around the purification unit for about 2.5 hours until control was achieved. It took another hour for full extinguishment.

Combustible materials associated with electrical and communication cables, instruments, various plastic materials were burned and contributed to the heat stress to which the equipment was exposed.

II. THE CAUSES OF THE LOSSES

As further explained below, the causes of the losses are:

- (1) Reboiler, item 3-E-8-2 exploded due to the effect of internal pressure.
- (2) Fluids discharging from the vessel expanded within and beyond the plant and flashed.
- (3) The flash fire caused extensive damage in the affected area, 20,000m².

The direct property losses are categorized as follows:

- (1) Fire damage is over 99% of the whole property loss.
- (2) Impact damage due to the flying of the parts of the exploding vessel.
- (3) Damage to the exploded vessel due to the internal pressure.

III. BATTERY DESCRIPTION

Following is a short preliminary description of the involved property:

Process unit involved:	EDC purification process battery.
Unit involved – HCL Column, item # 3D5 + 2 Reboilers	The column is made of 2 separate columns. The lower column containing 50 valve plates and the upper part containing 20 valve plates. The 2 Reboilers are connected to the lower section.
Item involved – Reboiler # 3-E-8-2	There are two such reboilers: # 3-E-8-1 & # 3-E-8-2. Only one item is in operation. The other is in-situ backup. The Reboiler is the heater of the column.
Nature of Item (the Reboiler):	Shell and Tube heat exchanger. Steam is flowing in the shell, EDC (and some VCM & HCL) in the tubes. The fluid is circulating from the bottom of the column through the operating Reboiler and back to the column. The steam flowing in the tube heats the fluid and causes it to circulate between the Column and the Reboiler. The Reboiler is thus the heater of the column and the steam is the driver inputting the heat.
Status of operation of the Reboilers during the Event:	During the explosion, the operating unit was # 3-E-8-1. The other item #3-E-8-2 was connected to the column but with no steam flowing, thus it was exposed to the pressure of the column, but did not participate in the heating. Item #3-E-8-2 (not in operation) exploded.
Reboiler other details:	Heating area – 71 m ² , Heat capacity- 1,425MCal. Dia. – 73cm, Length-about 400cm, Wall Thickness: 7mm+3mm for Corr. Allowance.
Normal operating conditions in the Reboiler:	12 bars & about 100°C±120°C in the tubes space, 8÷9 bars – shell (Steam side).
Typical Temperature & Pressures in 3-D-4 Column:	Lower column with Reboiler: 100-110°C. Upper column: -35°C. Pressure: 12.2 bars (bottom).
Max. probable pressure:	21 bars, determined by the safety valve.

Battery Description, Cont-ed.,

Purification Principle:	<p>The system is the stage following the EDC cracking process battery.</p> <p>The cracking products are: VCM, HCL, un-reacted EDC and some by-products.</p> <p>The Purification process uses the different boiling¹ temp. of HCL (-85°C), VCM (-13°C) and EDC (83°C) to separate between them, using heating and chilling circles.</p> <p>Heating is generated in the Reboiler by steam.</p> <p>Chilling is applied by chilled HCL flushed into the HCL upper section of HCL column 3-D-4.</p>
Composition of materials within the HCL column 3-D-4.	<p>Bottom: EDC, VCM and traces of HCL.</p> <p>Upper section: Condensed traces of EDC and VCM. Main fluid is HCL.</p>
Operational Status of the Plant:	<p>Start-up. Plant was shut-down after a fire that occurred in one of the Cracking units, date: 07-Oct-2003.</p>
Start-up time:	<p>First start-up 12 Oct, 1pm, 2nd Start-up 5pm.</p>
Problems during Start-up-Difficult Starting:	<p>1st start stopped due to leakage.</p> <p>2nd start encountered refrigeration system malfunction causing high system pressure and several hours pause and operational problem with Reboiler Item #3-E-8-1 that necessitated switching to the back-up Reboiler item #3-E-8-2.</p>
Operational Status:	<p>System stabilized at about 06:30 with operating Reboiler item #3-E-8-2</p>
Upset Pressure during last Start-up:	<p>16 bars, due to operational problem of the refrigeration system that keeps the HCL pressure at 11 bars at the top of the column.</p>
Nature of damage – Explosion of the Non-operating Reboiler #3-E-8-2	<p>The bottom dished head ruptured releasing the fluids within the column and from associated units through the opening created in the bottom of the Reboiler vessel.</p>
Cause of Explosion:	<p>Thinning of partial area in the bottom dished head to below the size that allows sustaining the normal pressure at the time of the event.</p>
Most of the damage is caused by ensuing ignition of the vapor clouds.	<p>The fluids discharging through the Reboiler were ignited creating large scale fire and local explosion within an area having a diameter of 220 m.</p>

¹ Indicated Boiling Temperature are at ambient pressure. At 51.2°C HCL is in Gas phase regardless of pressure.

IV. EVENT DESCRIPTION

At about 07:20, a vertical unit called "Reboiler" exploded. The lower dished head was detached and the contents of this unit as well as the whole "EDC Purification (or Distillation) system was discharged from the open bottom.

Further discharges occurred later from bursting rubber bellows connecting two graphite heat exchangers to other equipment in the area of column 3-D-5. These discharges were caused by fire damaging rubber bellows.

The system includes mainly: Columns 3-D-4, 3-D-5 & 3-D-6 as well as Tank 3-D-6 that contains EDC, VCM and HCL.

The discharge consisted of a mixture of EDC, VCM and HCL.

The resulting cloud expanded and was ignited. It created high temperature flash having a diameter of 200 to 240m. around the process unit. The flash extended outside the VCM battery limits, up to the PVC-3 plant in the west and to areas within the battery limits of the plant power station in the north.

Further liquid that was not burnt in the initial flash was burning around the purification unit for about 2.5 hours.

Combustible materials associated with electrical and communication cables, instruments, various plastic materials were burned and contributed to the heat stress to which the equipment was exposed.

The Reboiler is one of two units serving alternatively the "HCL Column" (3-D-4) as "**Column Heater**". It is a shell and tube heat exchanger. The heating media is steam flowing in the shell side at pressure of about 9 bars. The heated media is mainly EDC. The heating creates natural convection driving the EDC liquid from the bottom of the column through the bottom of Reboiler and back to the column from the top of the Reboiler.

The operating conditions in the Reboiler are: 12.2 bars, 100-120°C.

During start-up, the Reboiler - 3-E-8-2 was used while the parallel 3-E-8-1 was disconnected. When the operators realized that it is not efficient (partially clogged) they switched form it to 3E8-1 unit. The 3-E-8-2 unit remained open to the column but the steam supply was disconnected. Clogging of the first Reboiler is normal for start-ups.

The event occurred during start-up just after a balanced status was achieved in this column as well as the next VCM column 3-D-5.

It should be noted that during the 2nd startup attempt, there was an "upset condition". The HCL refrigeration system had some instrumentation problem. This caused increase of pressure in the "HCL Column" to around 16-17 bars. This high pressure status prevailed for several hours until sorted out.

The following photos show the main areas of the damage as the extent of the flash to the west and the north-east (Power Station).

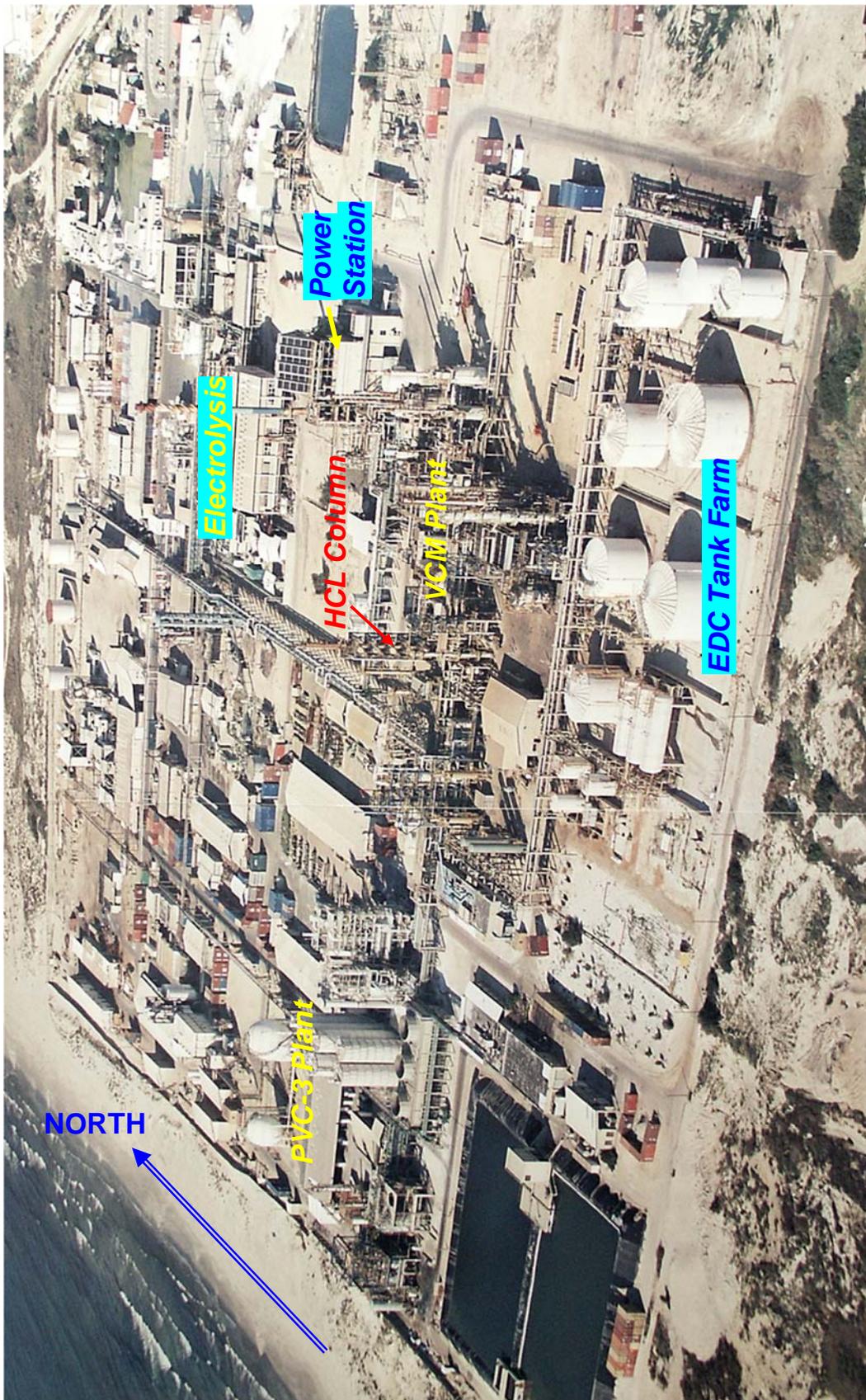
Other areas are not shown in this series.

Event Description, Cont-ed.,

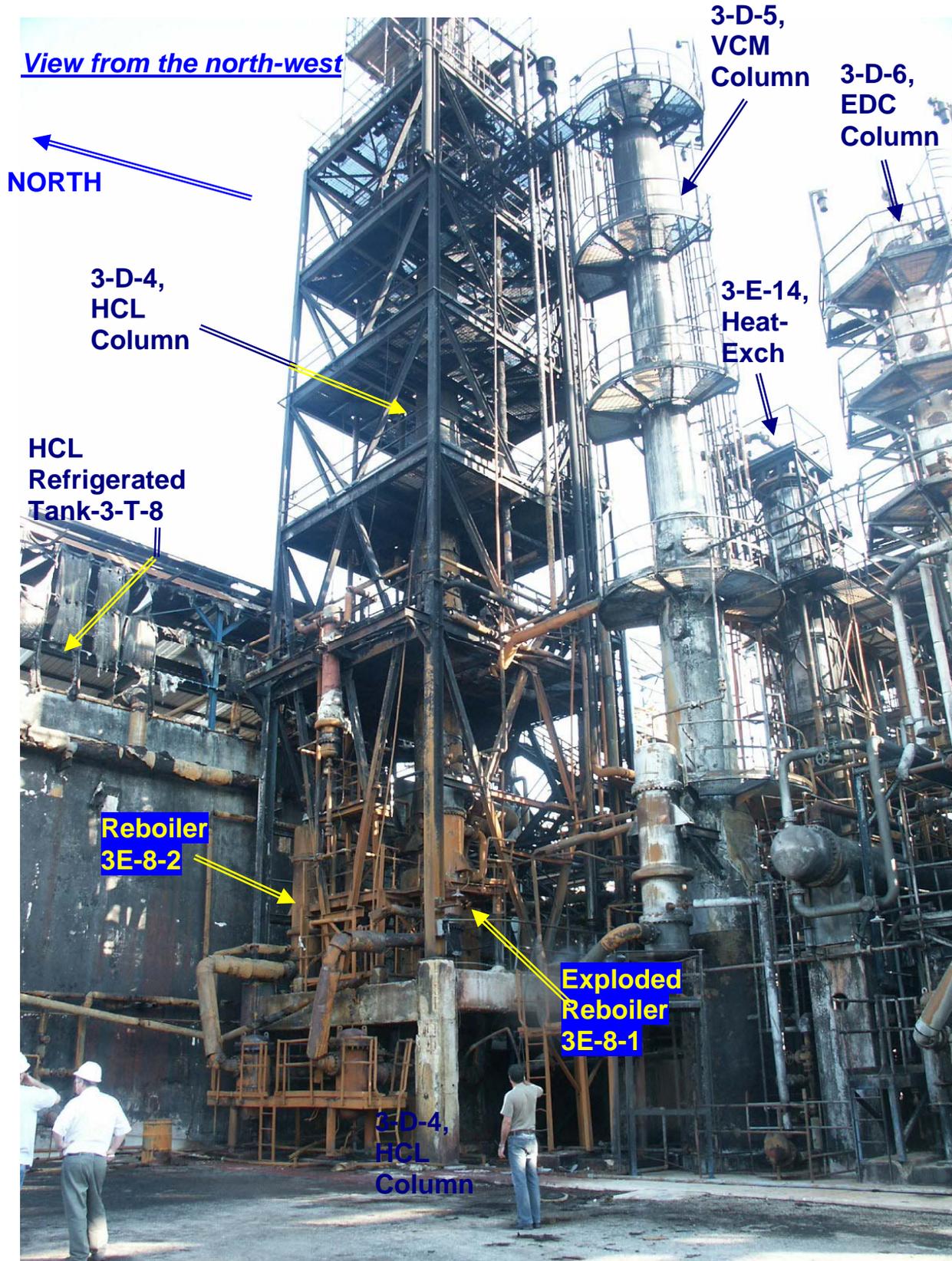
Notes:

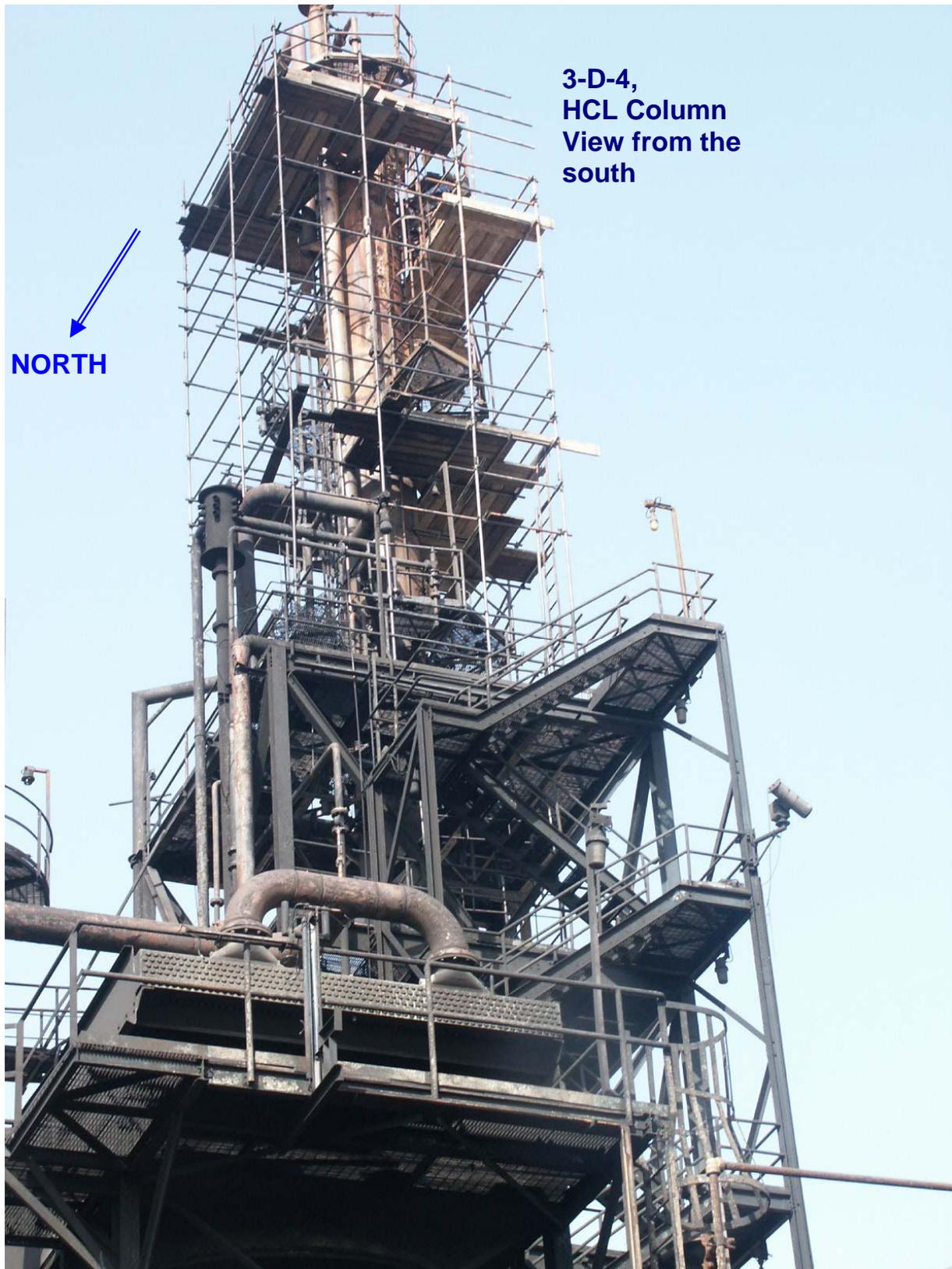
- (1) Thinning of a part of the area of the Reboiler lower dished head to below 1.5mm is extraordinary.
- (2) The parallel Reboiler and an additional spare unit had their thicknesses measured after the occurrence and found in the range of 5.5-6.5 mm.
- (3) The reboilers are exchanged between them periodically, so that there is no question of one unit serving more than another.
- (4) There was an extensive thickness measurements taking place in the column and piping in last April.
- (5) The unit was cleaned and tested in July 2003 and reinstalled in August-2003.

See photos and explanations in the following pages.



PLANT OVERVIEW - AREAL PHOTO -1999







Exploded Reboiler 3E-8-1
Lower head detached



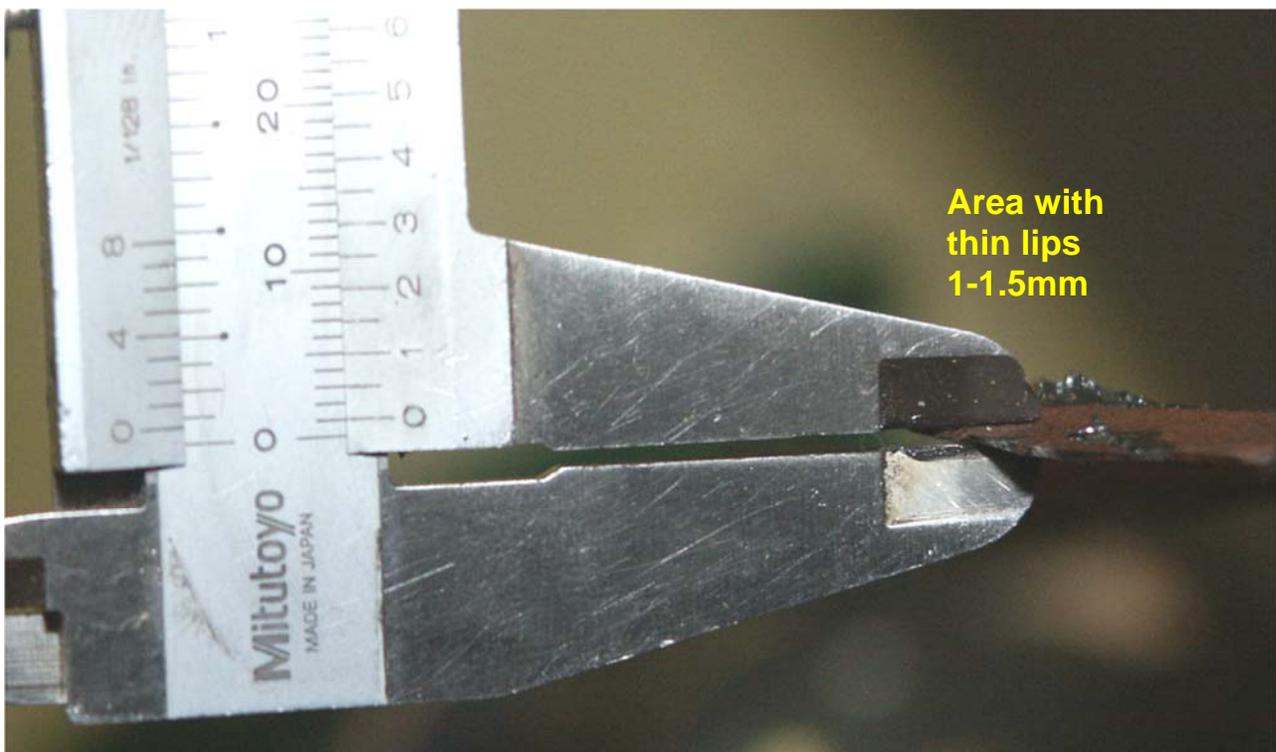
Exploded Reboiler 3E-8-1
The tube ends and tube sheet may be seen

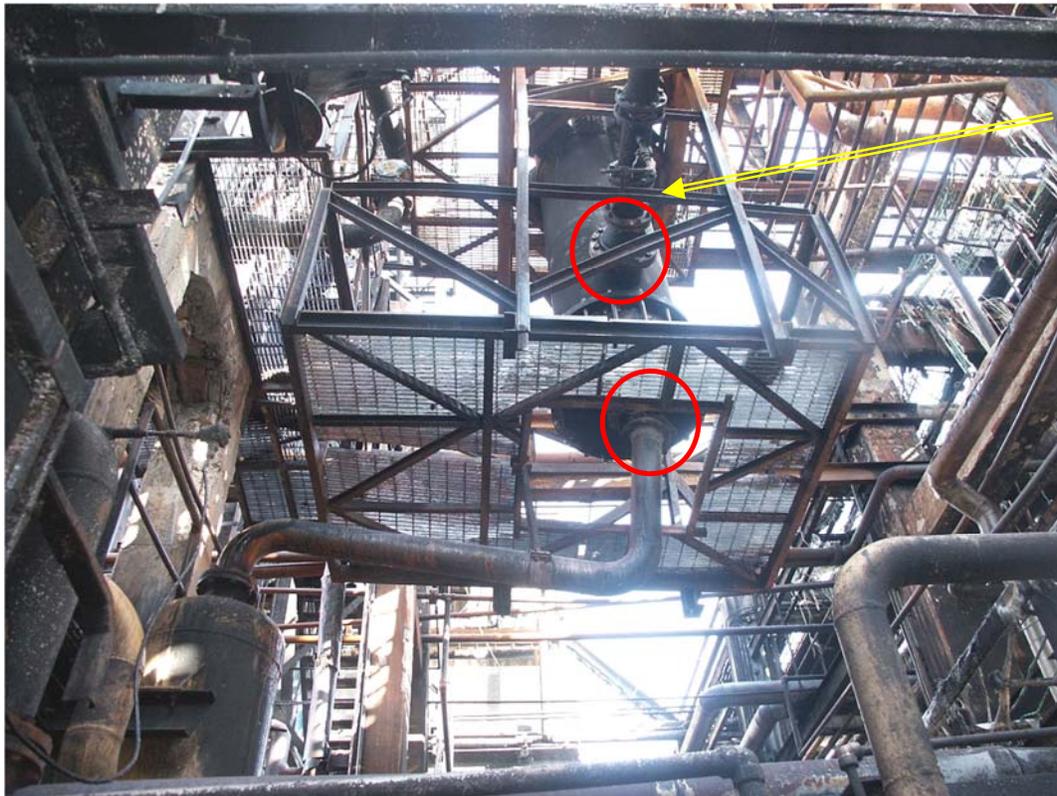


Steel- Boiler Steel – HII as per German DIN
Equivalent to ASTM A516.
Possible Yielding when $t < 2.6$ mm under $P = 17$ bars.
Possible Bursting when $t < 1.2$ mm under $P = 12$ bars.
 $T = \text{Thickness}$, $P = \text{Pressure}$.



The detached lower dished head - flattened by the impact

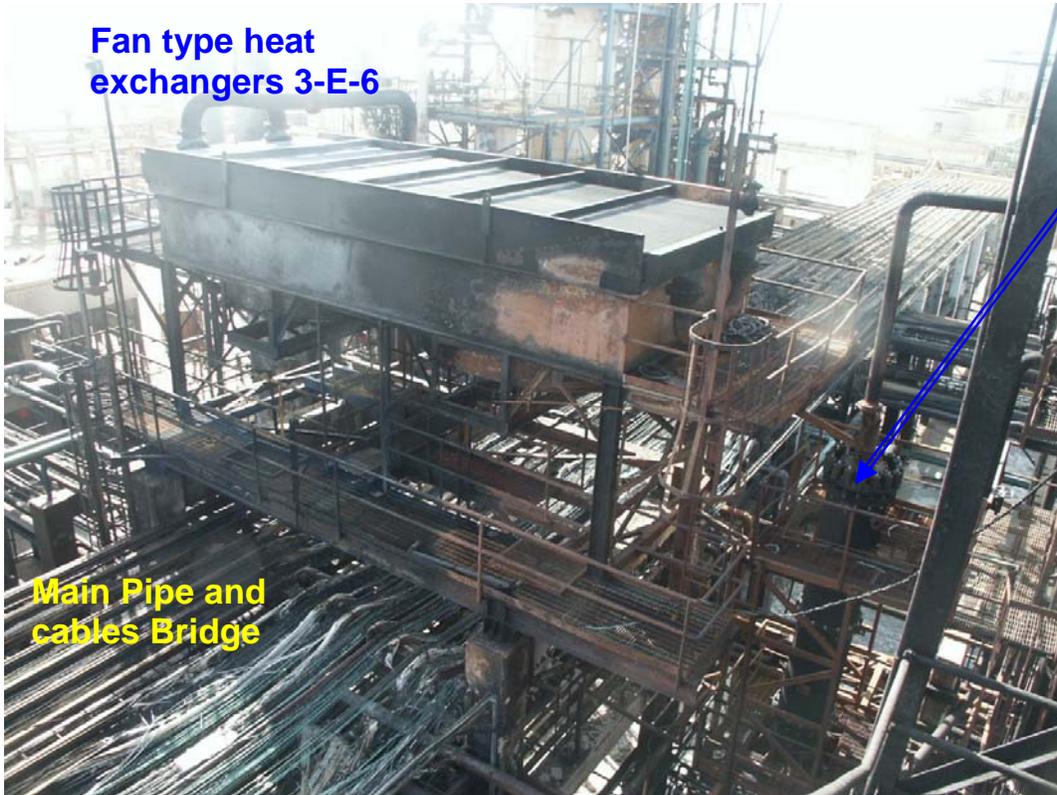




Graphite Heat exchanger – south of the 3-D-5, VCM column.

Fluid discharged through bursting bellows

Severe fire in this area.



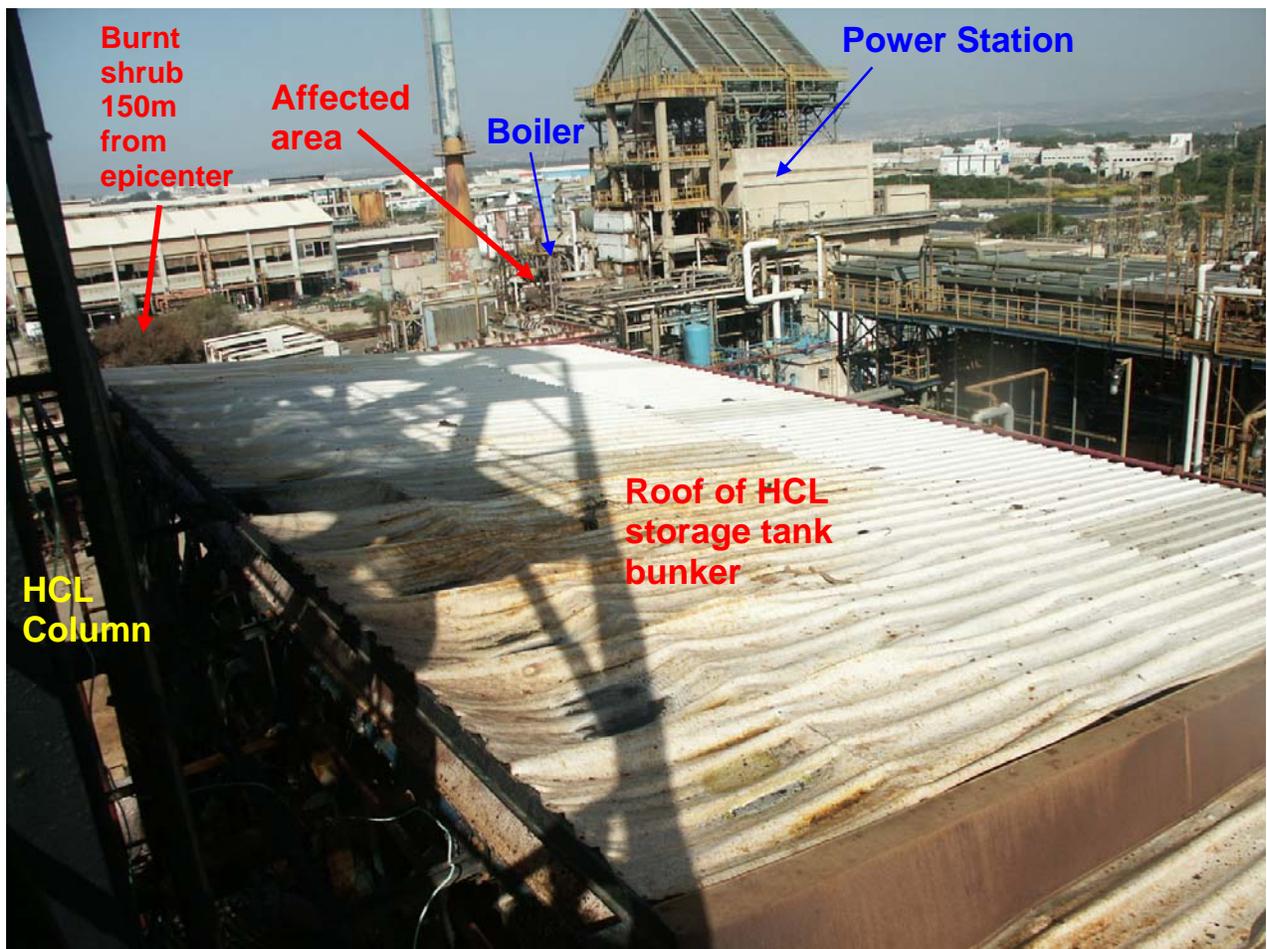
Fan type heat exchangers 3-E-6

Graphite Heat exchanger as above

Severe fire in this area.

Main Pipe and cables Bridge





V. CAUSE OF ACCIDENT

An enquiry team was formed and was handed with the task of determining the circumstances leading to the accident.

As noted the accident occurred during start-up following the previous mishap in one of the crackers.

The cause was pressure explosion in one of the Reboiler of the HCL column, see photos in pages 5&7 above.

The bottom head thickness in a certain limited area was too thin (down to 1.0-1.5mm) to withstand the pressure of 12 bars.

The thickness in the same areas was measured in the parallel unit and in a spare unit and found in the range of 5.5 to 6.5 mm.

So the thinning in the exploding unit was extraordinary.

The unit was taken out in July, cleaned and hydraulically tested at 20 bars. It was remounted in late august.

One process upset was detected. Due to some instrumental malfunctioning, the HCL Refrigeration system failed to operate. This caused an increase in pressure to 17 bars. This high pressure status prevailed for several hours until corrected.

No fault was found in the operators handling of the start-up.

The emergency behavior of the operators was excellent. Emergency valves were closed swiftly and electrical supply tripped. Water monitors were operated by the operators around the burning areas using water supply from the plant 4 diesel pumps.

It should be noted that the initial 1000m³ of fresh water were used as well as several thousands cum of back-up brackish water.

Water was also used to smother HCL gas with the effect of HCL acid descending on the equipment.

Fire services were called at 0724-25. They arrived at 0732 with 3 engines and took charge of the fire fighting. Three (3) additional engines arrived later.

Fire control achieved at 10:00.

Full Extinguishing was achieved at 11:00.

VI. OUTLINE OF DAMAGE

We hereby define the "heat affected zone" as the area where the flash fire occurred and scorching, soot, concrete damages are apparent.

The list below does not include the business interruption as defined under Section III of the insurance Policy,

No.	Subject	Damage
1.	Flash Fire Damage	Plastic based materials such as cables, tubes, instrument cabins, covers, seals throughout the VCM plant and in the Power Station auxiliary systems. Some minor damage is apparent in the PVC-3 and EDC Tank Farm
2.	Structural Damage:	Within and around the EDC purification process unit and the adjacent main bridge pipes and cable. The pressure waves caused damage to concrete columns and beams (external layers) within the heat affected zone of the flash. Burnt paint throughout the heat affected zone. Various extent of damage to instrumentation housings in the VCM plant. Asbestos cement sheeting in various sheds within the heat affected zone. Dislodging of insulation and fire proofing of vessels and piping.
3.	Damage to Equipment:	Damage to vessels, piping, valves, heat exchanges, motors and pumps within the VCM plant. The damage is due to impact of the fractured parts, blast waves, prolonged heating and short period high temperature flash. Suspected damage to the HCL compressor system and to the Recycle Compressors. Probable damage to pumps & motor when fluids rushed to the venting hole caused rotation like Turbo-Generators.
4.	Damage to Power and Communication cables	Scorching throughout the heat affected zone and actual burning in the area of the Purification process unit, adjacent main bridge and various locations throughout the heat affected zone.
5.	Damage to Instrumentation	Throughout the heat affected zone and within the control Cabins.
6.	Soot damage:	Within the main Electrical House of the VCM Plant, the adjacent Generator room and surrounding high voltage system.
7.	Corrosion Damage:	This type of damage is growing both externally and internally. This is due to condensed HCL.
8.	Contamination Damage:	Except for the effect on the plant, the possible effects on foundations and soil are to be determined.
9.	Catalyst	The catalyst within the Oxychlorination and Incineration Reactors is lost. Some stocks held in the recycle compressors shed were lost as well.

Outline of Damage, Cont-ed.,

No.	Subject	Damage
10.	Other operating materials	To be determined.
11.	Stocks	Loss of EDC, VCM and HCL
12.	Other operating materials	Catalyst in the Oxychlorination Reactor and Incinerator.
13.	Loss prevention costs	Preserving work of the VCM plant and material use thereof.
14.	Stocks	Loss of EDC, VCM and HCL, to be determined.
15.	Start-up cost	To reinstate the operation.
16.	Engineering and Consulting work.	Cost thereof – 18% of the Loss.

V. PRELIMINARY LOSS ESTIMATE

The actual loss per item may rise due to unexpected problems, particularly due to **resulting corrosion**. Other items may change as detailed evaluation advances.

No.	Subject	Estimated Loss (\$)
1	Damage to Power cables and outside equipment in the flash heat affected zone, including explosion Class I- Div 2 equipment	2,200,000
2	Electric motors in the areas heat affected for long time	285,000
3	Electric communication cables, Junction boxes, Field instruments and Gas monitoring equipment	2,500,000
4	Reinstatement of reinforced concrete columns and beams	100,000
5	Reinstatement of steelwork in the EDC Purification area and the main installation bridge	150,000
6	Reinstatement of pipe work	800,000
7	Damage to Process Equipment – direct	3,500,000
8	Reinstatement of HCL and recycle Compressors	200,000
9	Removal of soot, remains of burnt paint and solidified heavy materials, surface preparation and repainting of 90% of the VCM plant and other areas within the heat affected zone.	750,000
10	Cleaning of VCM's electrical room and Generator hall and equipment therein	100,000
11	Total Reinstatement	10,585,000
12	Engineering and Inspection -	1,852,375
13	Initial fitness for service inspection	15,000
14	Main fitness for service analysis as per API 579	50,000

18%

Preliminary loss estimate, Cont-ed.,

No.	Subject	Estimated Loss (\$)	
1	Catalyst	350,000	
5			
16	Other operating materials	50,000	
17	Fire Fighting cost and charges	40,000	
18	Damage to stocks	60,000	
19	Loss Prevention measures (Initial Estimate):	300,000	
20	Repairing roofs and walls of various sheds	60,000	
21	Removal of debris including asbestos cement sheets	120,000	
22	Cleaning contaminated ground		TBDM
23	Start-up cost	150,000	
24	Sub-Total	13,632,375	30%
25	Following Corrosion Potential damage, plant and foundation as well as unexpected/unaccounted losses– 30% of above	4,089,713	
26	Total Reinstatement	\$17,722,088	

We are carrying out more detailed evaluation of the losses.

In parallel we summoned four (4) leading engineering firms to provide offers for "Fitness for Service study". We expect that the chosen company will carry out the "level 1 assessment" within 7 days starting from order.

Attached hereto charts of "Fitness for Service procedure" as per API 579.

Yours faithfully,

Dan Arbel

DAN ARBEL RISK ENGINEERING Ltd.