EXPLOSION IN VCM PLANT IN 1988

1. BRIEF DESCRIPTION OF THE PLANT

Norsk Hydro's VCM plant is located at Rafnes, some 120 km south west of Oslo.

The plant is based om B. F. Goodrich Technology. Design capacity was 300 000 metric tons VCM per year in 8000 operating hours. This corresponds to 900 tons VCM per day. The plant was started up in 1978.

As a result of several debottlenecking activities, the capacity has been increased. At the time of the accident, the capacity was 1200 tons a day.

Figure 1 shows the general lay-out of the plant.

2. MODIFICATIONS IN THE CRACKING AREA

The plant had two crackers with accompanying quench towers. (A cracker No. 3 has been installed during summer 1989).

Two important modifications in the cracking quench system are shown in figure 2. Originally the quench tower had a bottom circulation system. EDC/VCM/HCl at a ratio of about 87/9/4 and a temperature around 175 ^{o}C was circulated by a pump. The liquid contained some coke and there were constant troubles with the pump's mechanical seal. We also had indications of stress corrosion cracking in pipes and valves. In 1981 we therefor replaced this system with a submerged inlet into the quench tower.

The second important modification was carried out in 1984. To conserve energy, a steam boiler and a feed preheater were installed in the quench overhead.

3. BRIEF DESCRIPTION OF THE INCIDENT

A pipe ruptured in the reflux line. The gas cloud that formed was ignited by one of the gas burners in the crackers. The distance from the leakage point to the burner was about 35 meters. The amount of EDC/VCM in the vapour cloud is estimated to 2-3 tons. In addition some 5 tons of liquid leaked down to the ground and was ignited. The fire already started had serious secondary effects: The outlet line from a liquid hold up tank ruptured and poured some 35 tons of EDC/VCM into the fire. The cracker feed line also ruptured, and a similar amount of EDC/VCM was released. This line also was bent out of position and directed a torch onto a cable rack.

The line feeding chlorine to the DC-reactors also ruptured, and som 5 tons of chlorine were released.

No persons were injured.

No main equipment, e.g. heat exchangers, tanks, towers, pumps etc, was destroyed. The main areas of destructions were:

- pipes; several hundred meters of piping had to be replaced
- cables; both instrument (pneumatic) and electric
- instrumentation
- a concrete structure in three levels was severely exposed during the fire. It was not damaged beyond repair. A special technique was applied in order to extract chloride from the concrete.

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4. DETAILS ABOUT THE PIPE RUPTURE

A detailed drawing of the pipe fitting where the rupture occured is shown in figure 3. The design of this fitting was unfavourable in several respects:

- The liquid flow was turned 180 degrees.

- The T-piece had a much greater wall thickness than the rest of the construction.

- Some internal welding seams had a protrusion of about 5 mm.

- There are indications that the bend that ruptured, initially had a wall thickness of only 3 mm instead of 3,6 mm.

In appendix 4 are given some data for the reflux stream. The most important differences between present (1988) and initial figures are:

- Higher velocity
- " pressure
- " temperature

The coke concentration given is very uncertain, it represents just one single sample. However, it seems likely that higher throughput and submerged inlet instead of bottom spray nozzles will have a tendency to increase carry over of coke. The higher reflux flow on the other side should have the opposite effect.

5. CAUSES OF THE RUPTURE

The most likely causes for the thickness reduction in the bend that ruptured, are erosion and corrosion. These two factors will be discussed in more detail.

5.1 Corrosion

The piping was made in carbon steel. This is considered an adequate material as long as this process fluid is dry. The water content has normally been below 10 ppm. At this water level corrosion is very slow.

In order to monitor the condition of the piping system, a program for ultrasonic thickness measurements was established at plant start up. The program included 51 measuring points at the reflux system. At the time the program was worked out, erosion was not considered as a problem. Accordingly, all measuring points were on straight parts of the pipes. The reason for this was that ultrasonic measurements with the available equipment were less reliable on bends.

In the period from plant start up in 1978 to the fire in 1988, som leakages occured, both in bends and straight pipe. These leakages were caused by external corrosion under insulation. Further inspections revealed several cases of external corrosion, and also some cases of internal pittings. The general impression was that there was no significant thickness reduction due to internal corrosion.

5.2 Erosion

According to what is said in the preceding section, erosion must have been the main cause for the rupture of the bend. Erosion severeness will be dominated by the following three conditions: Fluid velocity, coke particles and geometry of the actual fitting.

5.2.1 Fluid velocity

Recommended values for maximum velocities of liquids flowing in pipes are hard to find. In a textbook being used at the Norwegian Technical University it is stated: "Liquid velocities over 4,5 to 6 m/s (14,8 to 19,7 fps) should be avoided to reduce erosion".

In a paper in Chemical Engineering by Charles R. Kent (September 25., 1978) is given a formula for maximum velocities for clean fluids. In our case this formula gives 3,8 m/s (12,5 fps).

Compared with the two previous figures, the actual velocity, 3,27 m/s (10,7 fps), does not seem excessively high. This is true as long as the reflux stream can be considered as a clean fluid.

5.2.2 Coke particles

Under normal operating conditions of the quench tower the carry over of coke is considered to be small. During short upsets, i.e. low liquid level and loss of ~~bottom~~ top spray, the carry over will increase. Some weeks before the incident a defect (leakage) was discovered in the spray system of one of the quench towers. This might have contributed to an increased coke carry over.

A sample of the reflux fluid was analysed for coke. The result was 300 mg/liter (0,03 %). The value seems low, but it is hard to predict the influence upon the erosive properties of the liquid.

5.2.3 Geometry of fitting (return bend)

The flow characteristics of the return bend was investigated using a fluid dynamis program (FLUENT). The investigation showed that high local velocities occured, especially in the inner curve of the bend. This is just where the rupture took place.

6. CONCLUSION

The fire in Norsk Hydro's VCM plant at Rafnes, Norway, was caused by a rupture in a return bend. Three factors are considered as the main reasons for the rupture:

- High liquid velocities
- Coke paricles in the liquid
- Return bend geometry with high local velocities.

The relative weight of these three factors are uncertain. In rebuilding the plant all three have been taken care of:

- Bigger pipe diameter
- Pipes with greater wall thickness
- Zig-zag baffles in the top of the quench tower to hold back coke particles and liquid droplets.
- Redesign of return bend
- Thickness measurement program to include also bends.

When operating with three crackers (see section 2), the velocity in the reflux line to each quencher will be 1,13 m/s (3,7 fps). This is by all standards a low velocity. This in combination with greater wall thickness, less probability of coke in the fluid, better design of return bend and a more extensive program for thickness measurement make us confident that the situation is under control in this specific part of the plant.

Rafnes, 06.09.89

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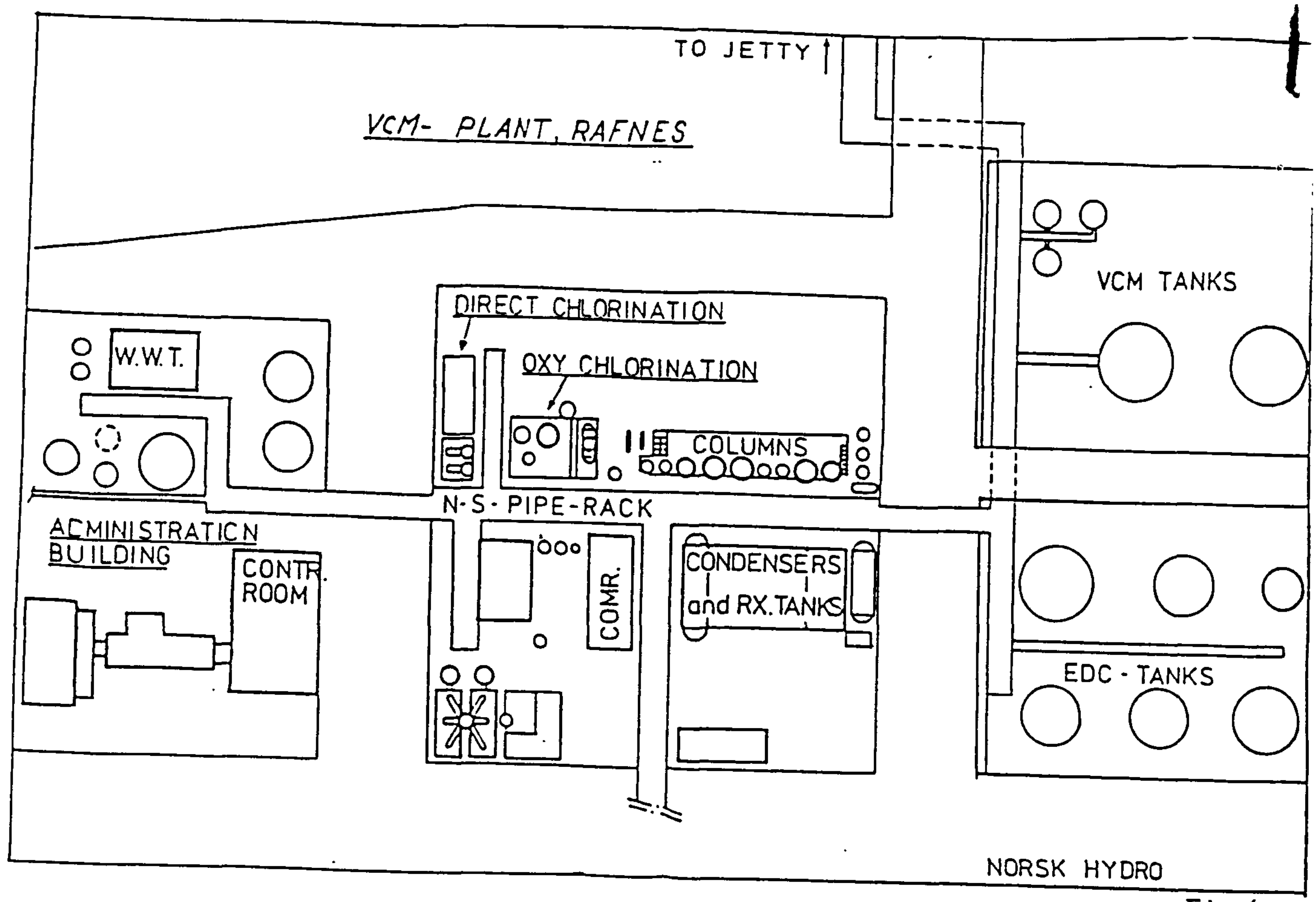

Fig. 1

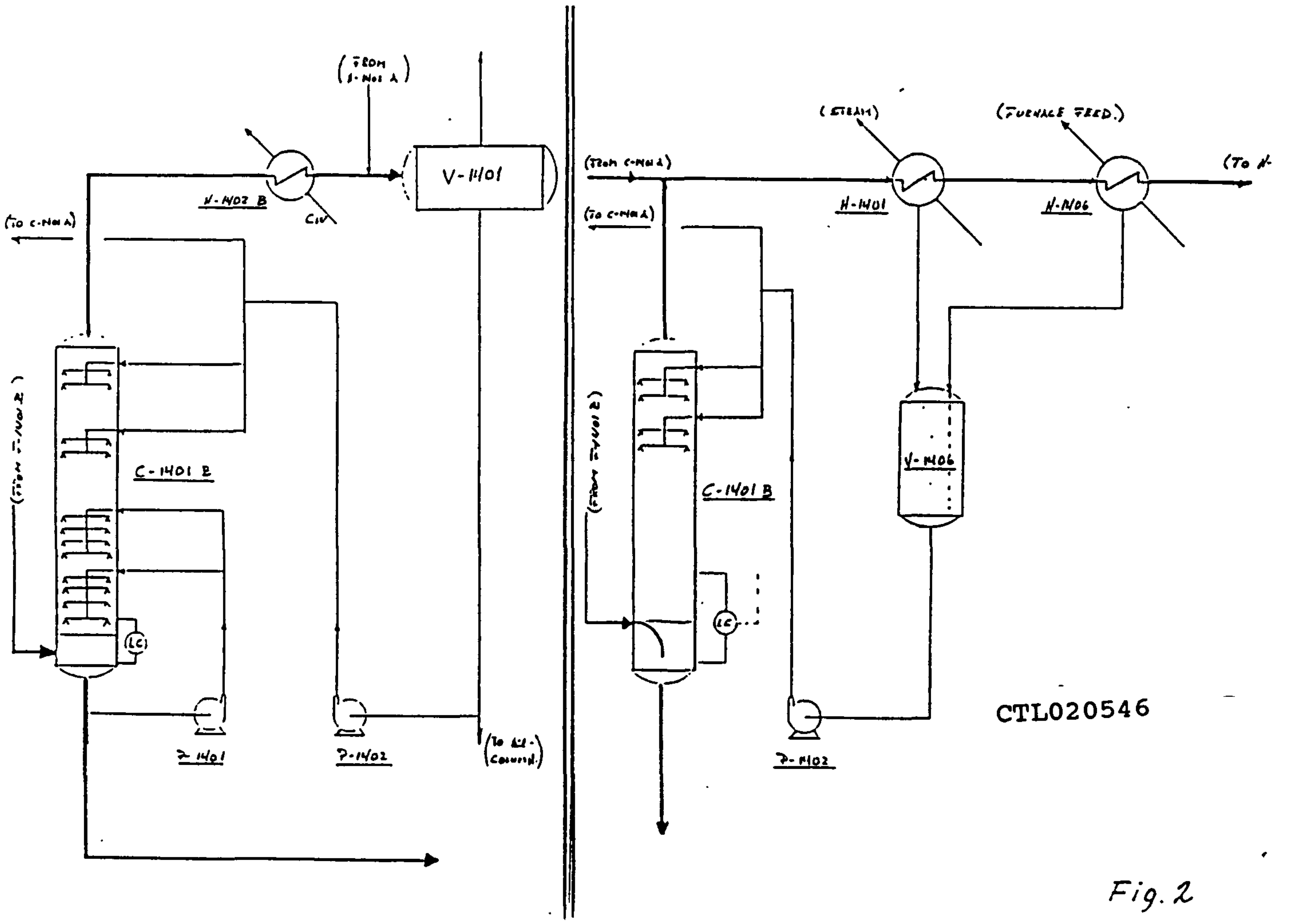

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Fig. 2

APPENDIX 4

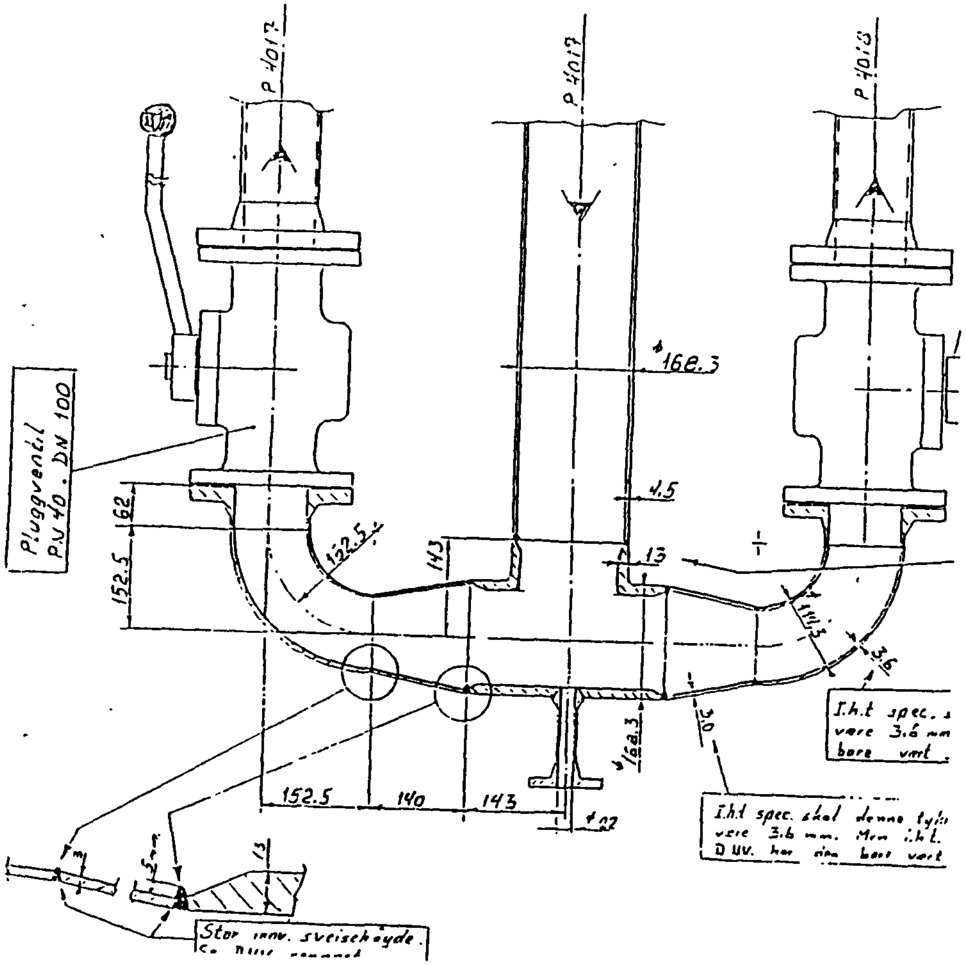

Fig 3.

REFLUX FLOW CONDITIONS

		Initial design	Present (1988) situation
Fluid flow	m^3/h	66	106
	gpm	290	466
Fluid velocity	m/s	2,04	3,27
	fps	6,88	10,7
EDC/VCM/HCl		91/8,5/0,5	88/10/2
Pressure	bar	24	30
	psig	348	433
Temperature	^oC	57	146,5
	^oF	135	296
Coke	wt %	-	0,03
	mg/ltr	-	300