

Flixborough petrochemical plant, 1974

- The Flixborough works of Nypro (UK) Ltd were virtually demolished by an explosion of warlike dimensions on the afternoon of Saturday 1 June 1974.
- The explosion was estimated to be equivalent to the force arising from 15 – 45 tons TNT. This was due to ignition of a vapour cloud which formed when pressurised cyclohexane (a petrol-like substance) escaped from a reactor, vaporized and ignited.
- On site 28 people were killed and 36 injured; if the explosion had occurred during the week there would have been many more casualties.



Flixborough – the site

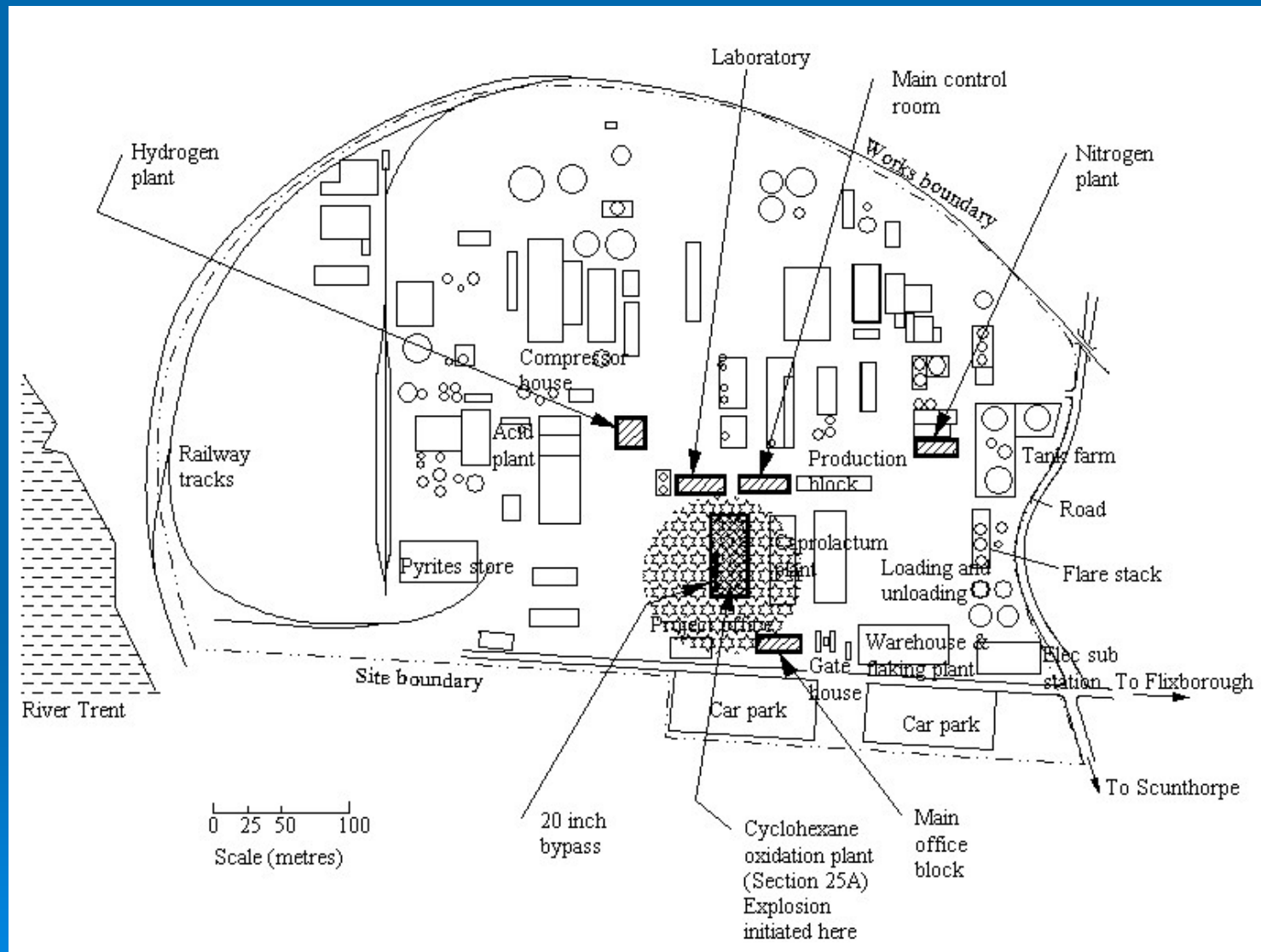
The 60 acre Nypro works were owned by Dutch State Mines (55%) and the National Coal Board (45%).

The works were situated on low lying ground to the east of the River Trent and was surrounded by farms and fields with, fortunately, a low level of population.

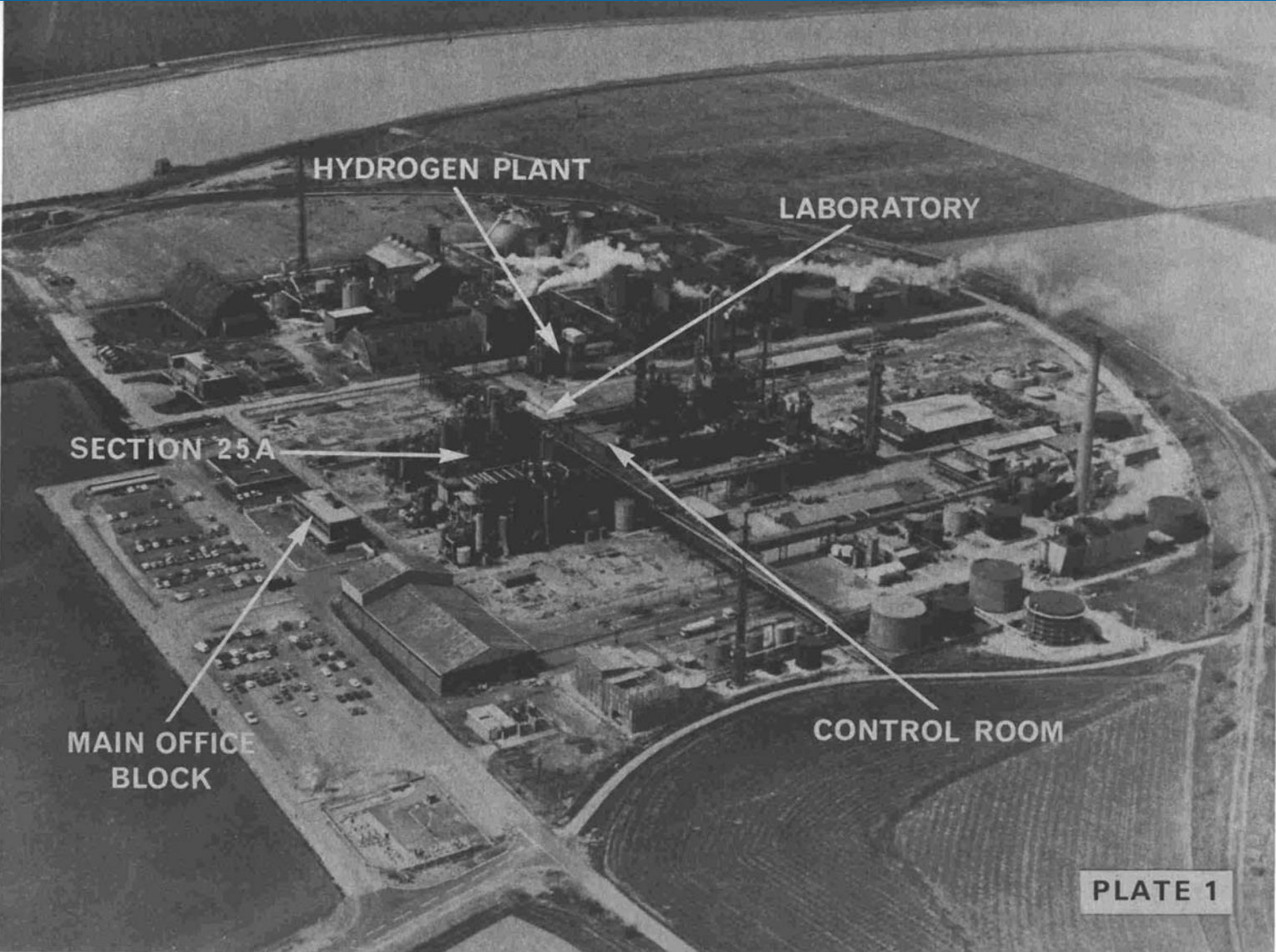
The villages of Flixborough and Amcotts were roughly half a mile away from the works across the river, while Burton-upon-Stather was 2 miles away. The town of Scunthorpe was 3 miles away.



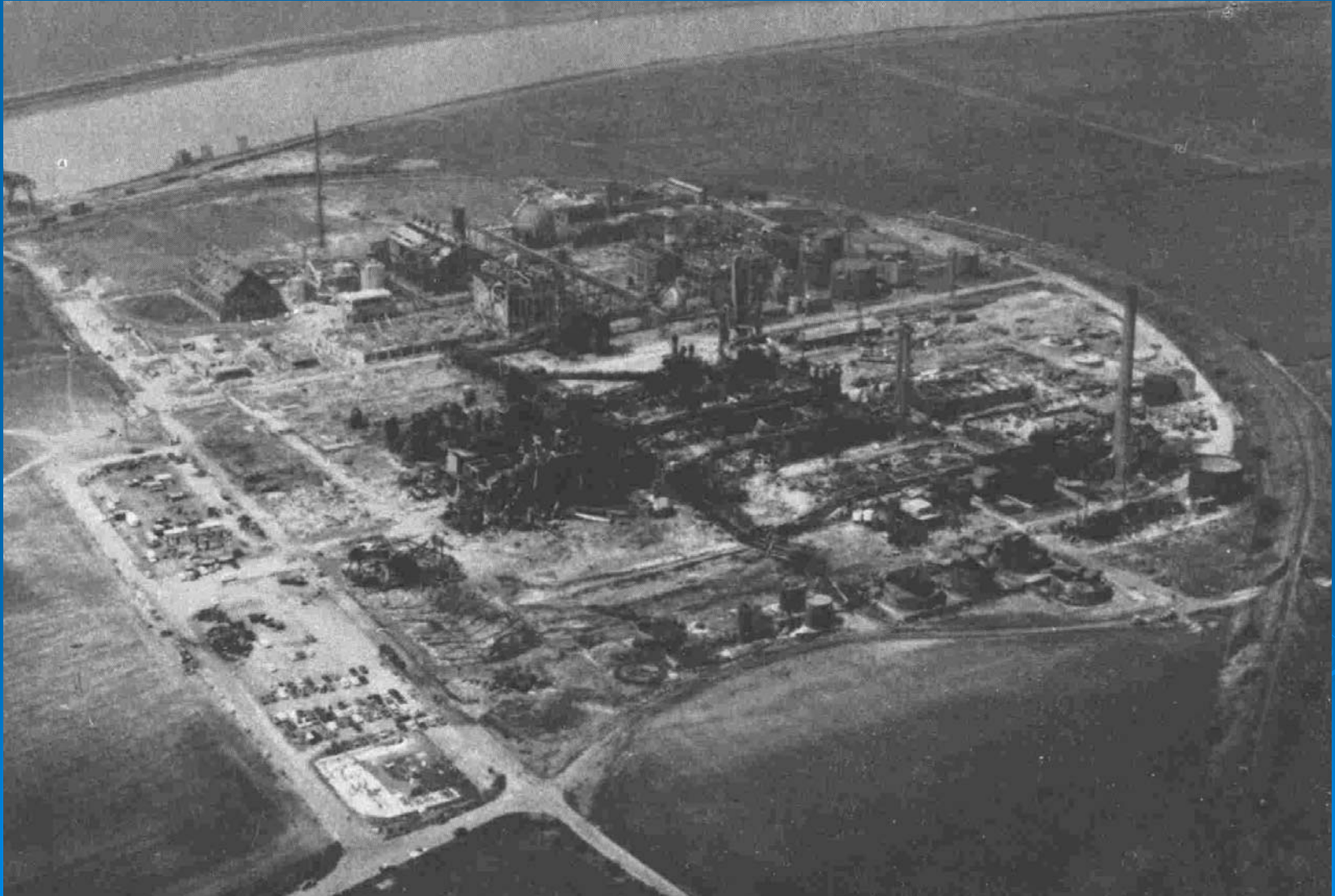
The Flixborough site



Before the explosion



After the explosion



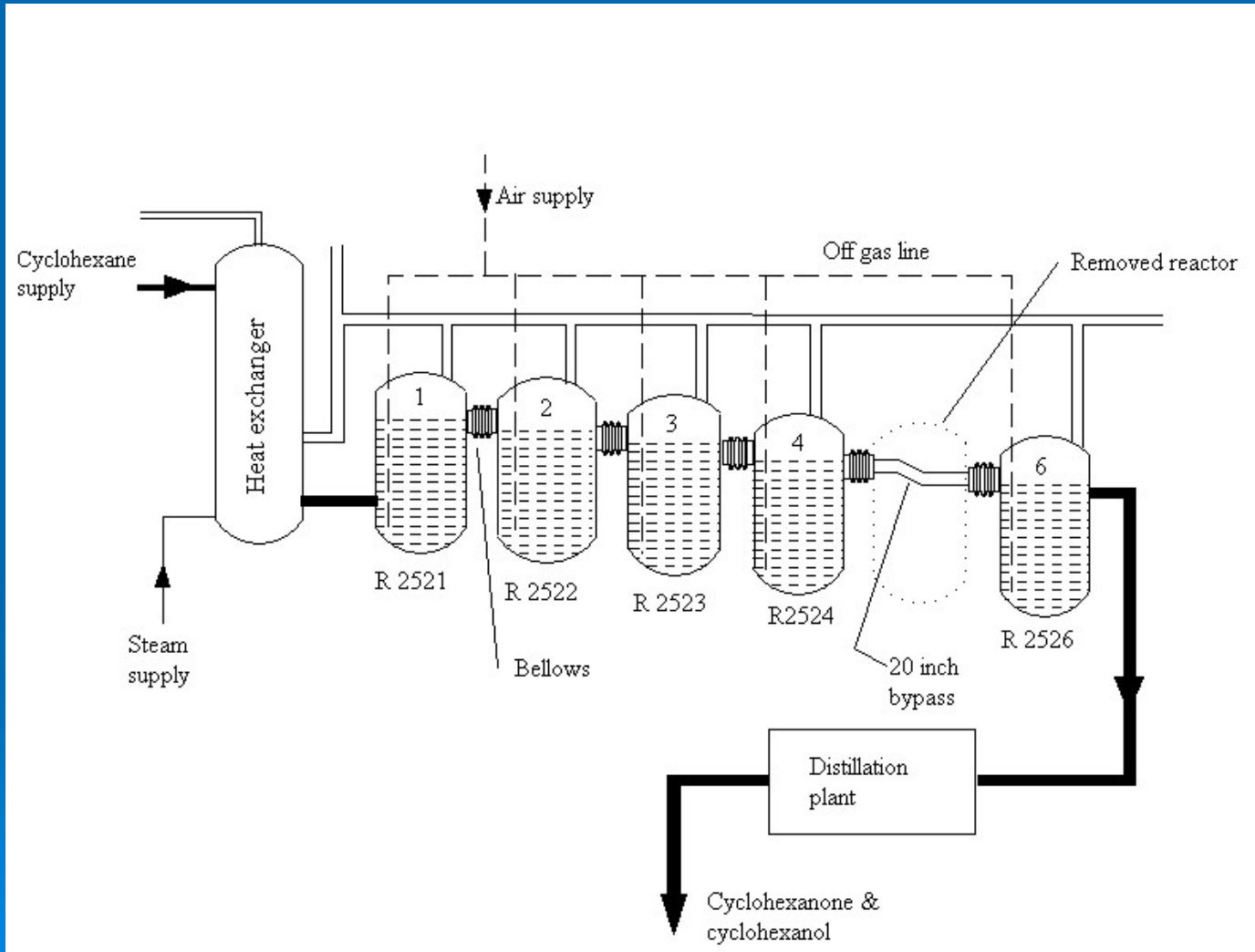
Flixborough – defective pressure vessel



- Failed pressure vessel taken out of service. Note crack propagation near flange.
- Square holes are where material has been removed for examination



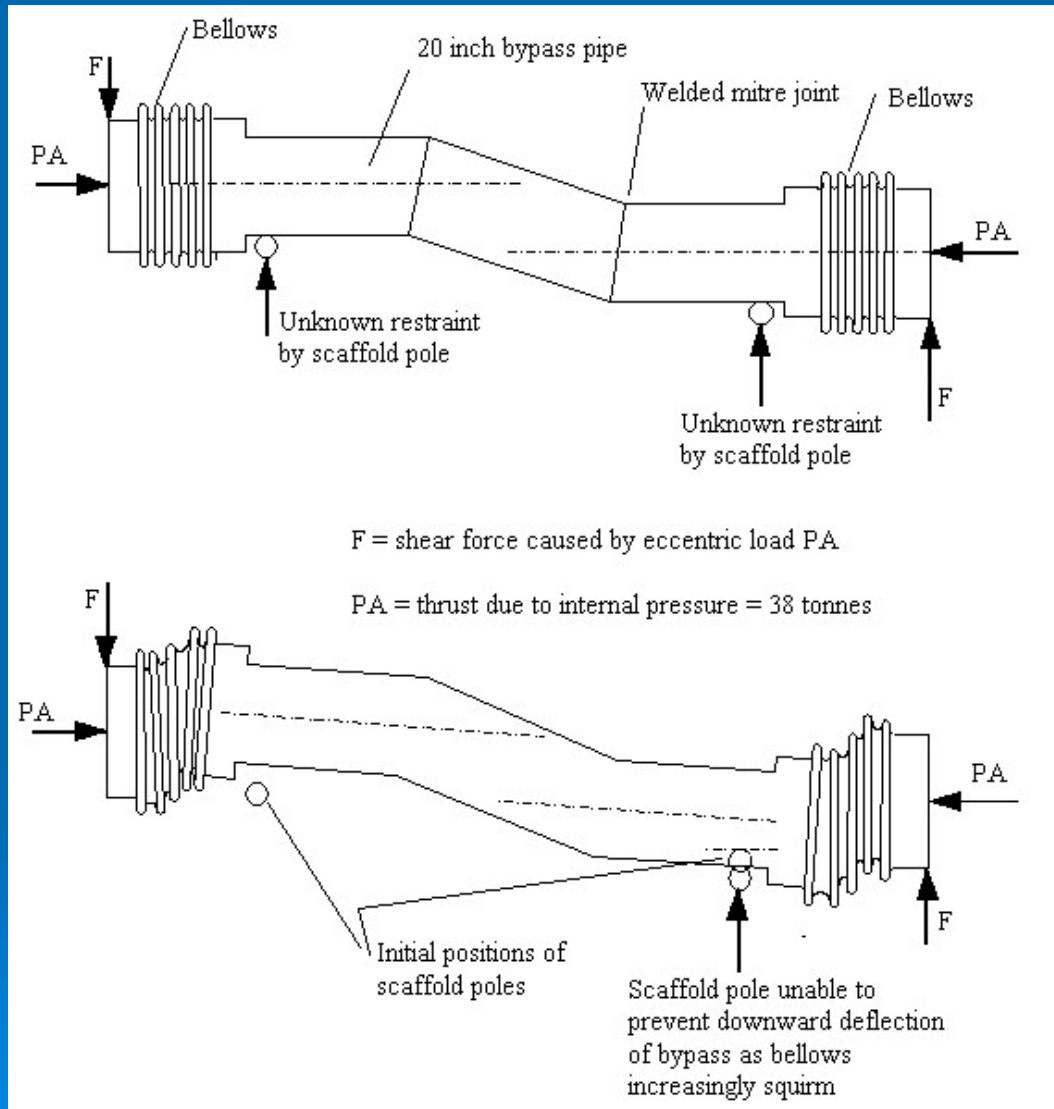
Flixborough – Section 25



Shows removed pressure vessel replaced by standby pipe.



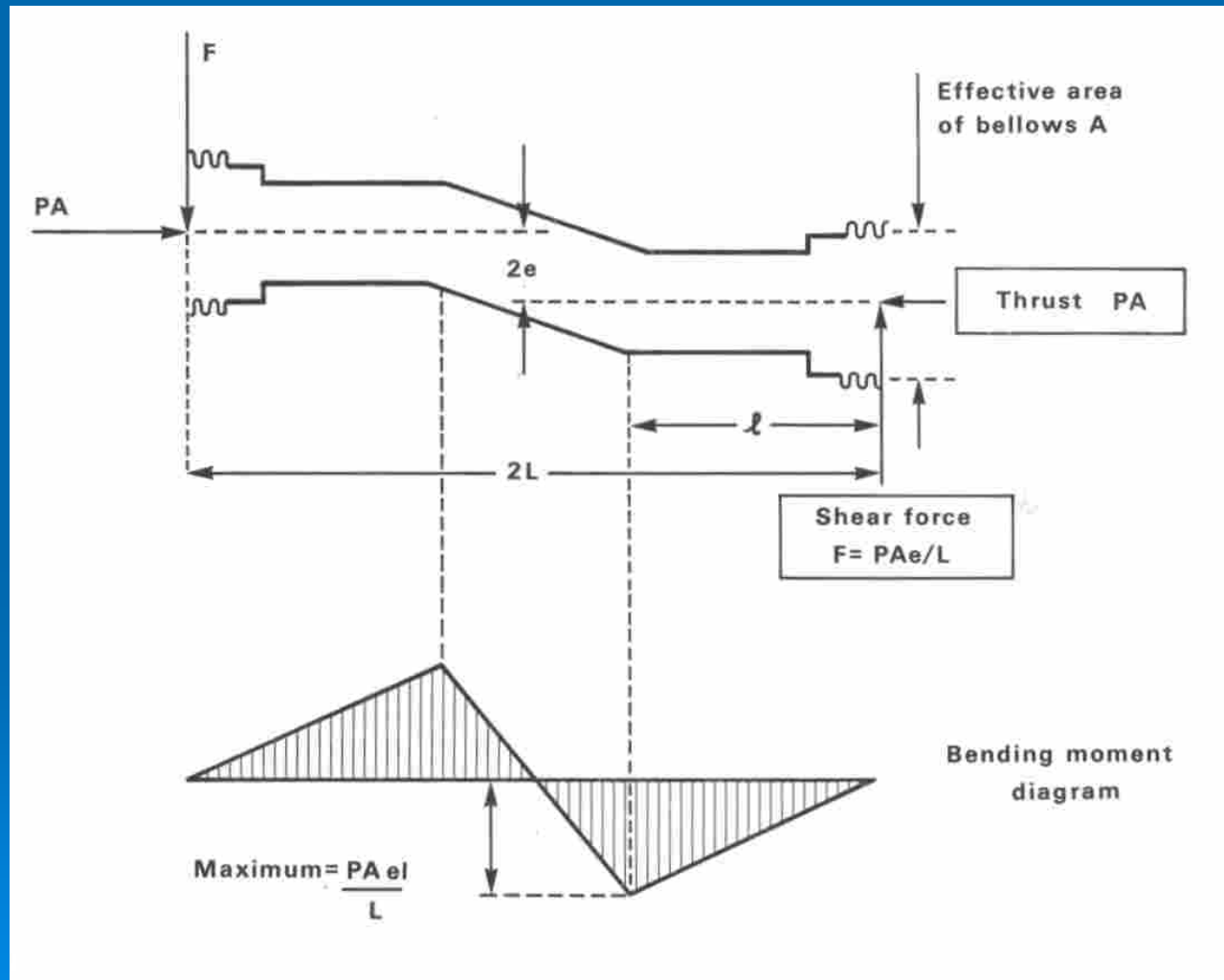
Flixborough – bypass pipe



- Details of the support for the cranked bypass pipe.
- Pipe was supported by scaffolding poles. As pressure built up the bellows displaced vertically downwards at one end and failure occurred by 'squirming' and rupture of the mitred welds.
- The by-pass had not been properly designed (effect of axial force apparently overlooked).
- The liquid escaped and formed a vapour cloud which ignited in explosive manner



Flixborough – forces on bypass pipe



Flixborough – the explosion hypothesis

- The explosion occurred at 16.53 on Saturday 1st June 1974. The sequence of events is unclear.
- Two hypotheses were considered in the Inquiry report: failure of an 8 inch pipe and, separately, failure of the 20 inch by-pass as the pressure was increased (as the plant was being brought fully on line after the fitting of the bypass).
- The preferred hypothesis was failure of the 20 inch by-pass pipe which occurred by downward deflection of the supporting scaffolding pole followed by 'squirming' of the bellows and rupture of the lower mitre weld in the dogleg pipe.



Flixborough – the explosion hypothesis

(continued)

- This precipitated failure of the mitre weld and, under the action of the axial compressive load, caused the bypass to jack-knife, so allowing escape of cyclohexane.
- It seems likely that if the assembly had been tested to 11 kg/cm² the by-pass pipe and bellows assembly would have failed and the disaster would have been averted.
- The Inquiry report did not speculate on how the vapour cloud was formed in the Flixborough plant but recommended that further research was necessary on the required conditions for unconfined massive vapour cloud explosions.



Flixborough - observations

- The disaster was caused by poor design and inadequate structural support (with flexible scaffolding poles) of a temporary 20 inch diameter bypass pipe
- Structural calculations for the bypass were not carried out - such calculations might have anticipated the failure mechanism
- There was inadequate recognition by management that a calculation and proper pressure test was necessary for the bypass - there was no Works Engineer employed at the works at the time. There was too much reliance on chemical engineers in the management team.
- After the explosion the phenomenon of squirming was demonstrated with large scale tests on bellows subjected to shear force



Flixborough – observations

(continued)

- Information on the conditions necessary for the formation of large flammable vapour layers and the consequences of their ignition was not available.
- It was very fortunate that the plant was not located in an urban area (compare with the Buncefield oil depot explosion).
- Investigations revealed that parts of the plant including the failed reactor, had, over the years, suffered from nitrate stress corrosion. This is a phenomenon that all plant engineers should know about but apparently they do not.
- The Inquiry suggested that the training of engineers should be more broadly based, both academically and practically, so that they had some knowledge of other branches of engineering.

