



# Major incident investigation report

**BP Grangemouth Scotland : 29<sup>th</sup> May - 10<sup>th</sup> June 2000 A Public Report Prepared by the HSE on Behalf of the Competent Authority**



- **Contents**

## Legal basis

The powers of the Health and Safety Commission and the Health and Safety Executive (“the HSE”) are set out in the Health & Safety at Work etc. Act 1974. The Commission has the power to direct the HSE or authorise any other person to investigate and make a special report on a matter, or with the consent of the Secretary of State to direct an inquiry to be held into that matter. However, in relation to the matters addressed in this report the Commission decided that it was not necessary to direct the HSE to carry out an investigation and make a special report in terms of the Act, or to direct that an inquiry be held. Instead the Commission and the HSE agreed that the HSE would prepare this non-statutory report and would make it available to the public in accordance with the HSE’s policies. This report explains how and why the incidents occurred and the actions taken by BP and the HSE. The report will help industry to learn lessons from the incidents.

The extent of alignment of the HSE’s findings and recommendations with those of BP’s own investigations and BP Task Force is an important feature of this complex investigation. The HSE acknowledges BP’s openness and cooperation in their response to the incidents and in the preparation of this report.

**Note: All references to website addresses were correct on date of publication 18th August 2003. HSE will periodically review website links quoted.**

This Major Incident Investigation report has been produced by the Health and Safety Executive (HSE) on behalf of the Competent Authority.

The report contains a description of the following:

- The three incidents that occurred at the BP Grangemouth Complex between 29<sup>th</sup> May 2000 and 10<sup>th</sup> June 2000;
- The immediate response of BP following the incidents (this includes the investigation carried out by the BP Task Force);
- The series of investigations carried out by the Competent Authority in the aftermath of the incidents;
- The subsequent findings of the Competent Authority investigations.

The report also summarises the following:

- BP’s learnings from these incidents and the actions taken by BP;
- The key lessons for major accident hazard sites;

- Wider messages for industry.

The report contains hyperlinks to enable the reader to move around the report, and internet links to other information available on the HSE website and external websites. This allows the reader to access additional information directly from this report and hence to broaden their knowledge and understanding of the information described should they wish to do so.

Although the report is predominantly concerned with the series of incidents that occurred at the BP Grangemouth Complex in 2000 it is being published at a time when the HSE has embarked on the "Revitalising Health and Safety" strategy. This strategy aims to "prevent major incidents with catastrophic consequences occurring in high-hazard industries". The opportunity is therefore also taken to remind industry of its responsibilities with some messages from the HSE.



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Foreward - A message from Dan Mitchell, Head of Land Division, Health and Safety Executive

In response to public concern over the series of three major incidents at the BP Grangemouth Petrochemical Complex during May/June 2000 a commitment was given to produce a report summarising the Competent Authority's investigation. This report could not be published until the completion of legal proceedings for criminal offences. On 18<sup>th</sup> January 2002 BP Chemicals Limited and BP Oil Grangemouth Refinery Limited were each convicted of an offence under the Health & Safety at Work etc. Act 1974. BP Chemicals Limited were fined £250,000 and BP Oil Grangemouth Refinery Limited were fined £750,000. This reflected the seriousness that the courts hold for failings in controlling major hazard risks.

The Health and Safety Executive and the Scottish Environment Protection Agency jointly carried out the investigation under the COMAH Regulations where they operate as the joint Competent Authority. The Health and Safety Executive led the investigation team as safety issues predominated.

The Competent Authority believes it is important that the public in Grangemouth are openly informed of the way major hazard sites are regulated, of the investigations conducted and actions taken to improve health, safety and environmental performance on-site. It is also important that the chemical and oil refining industries learn the lessons from these three incidents and take the necessary measures to minimise the number of major accidents.

Recent work reviewing thirty years of "Large Property Damage Losses in the Hydrocarbon-Chemical Industries" published by Marsh provides a number of lessons for this major hazard industry and also shows that there was little new in the events leading to the BP Grangemouth incidents.

The Health and Safety Commission Strategic Plan for 2001-2004 details the initiatives underway by the Health and Safety Executive and challenges all who have an interest in the industry to 'revitalise health and safety'. For COMAH sites the plan sets the challenge for the industry, its advisors, and the Competent Authority to work together to reduce the number of major accidents by 20% by 2004.

Of a total of nine refineries operated in the UK overall three have had major accidents of sufficient seriousness to require notification to the European Commission in the space of one year. Only good fortune prevented workplace and public casualties from the Grangemouth incidents. Industry must not become complacent about the risks posed by major accident hazards.

BP comprises one of the world's largest group of companies and has committed itself to being a leader in health, safety and environmental management and performance both in the UK and worldwide. Their policy "Getting HSE Right (GHSER)" represents good business practice and corporate governance of risk. We welcome this commitment from BP.

In response to the incidents BP formed a BP Task Force to carry out a "root and branch" audit, the largest

ever assembled in the company's history.

The Competent Authority's investigation was complex and wide ranging extending beyond the plant and installations to human factors and safety culture. It was started immediately following the first of the three incidents and continued until legal proceedings were successfully completed.

The recommendations arising from the Competent Authority investigation closely aligned with those of BP's Task Force. BP has committed substantial resources to implement all these recommendations.

Since the incidents occurred there has been a sustained improvement in operational performance across the Complex. Work is continuing to maintain the momentum and is being integrated into the on-going business process.

The Competent Authority is committed to following up the recommendations in this report through our inspections and we will track the remedial action taken to ensure that BP's improved performance is sustained.

We would welcome any feedback from you on the investigation and this report. Email to [dan.mitchell@hse.gsi.gov.uk](mailto:dan.mitchell@hse.gsi.gov.uk).



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- **Background**
- **Description of each incident**
- **Competent Authority response**
- **Direct and underlying causes**
- **Findings and recommendations**
- **Key lessons for industry**

## Executive summary

### Background

The BP Grangemouth Complex (the Complex) is a **Major Accident Hazard (MAH) site** as defined under the **Control of Major Accident Hazard Regulations (COMAH) 1999** which implements the **Seveso II Directive** in the UK. It is one of the largest of the 950 COMAH sites in the UK.

The Complex is an important centre of UK operations for BP and of major strategic importance for the BP Group.

The COMAH Regulations require a MAPP (Major Accident Prevention Policy) to be produced for the Complex which requires a very high standard of management of major accident hazards to be demonstrated and that the operator will take all measures necessary for the control and prevention of major accidents.

Operators of “top tier” sites are also required to prepare safety reports which identify the systems used by the operators to ensure their processes are operated safely at all times and that adequate steps are taken, so far as is reasonably practicable, to prevent **major accidents** or in the event of such accidents, to limit the effects on people and the environment.

Such reports for the top tier installations at the Complex (incorporating a MAPP for the Complex) had been prepared and submitted to the **Competent Authority** for examination and assessment and were under review in May 2000 when the incidents took place.

Under the COMAH Regulations, operators are also required to provide information on safety measures at their establishments to persons likely to be affected by a major accident occurring at their establishment. On and off-site emergency planning is also a key component. The Complex had provided such information to the local authorities for inclusion in an off-site emergency plan and prepared an on-site plan.

The Competent Authority is required to carry out significant regulatory activity including inspections in order to ensure that the operations are being conducted in accordance with both legislative requirements and company claims as evidenced in the COMAH safety reports. Prior to the series of incidents that occurred in May/June 2000 the Complex was already the subject of significant regulatory activity and the HSE were in discussion with the management at the Complex concerning a number of safety issues which were of concern. The new Complex Director appointed in October 1999 had accepted that the Competent Authority concerns were valid at a meeting in November 1999 and a major management action plan was already underway to improve safety performance on-site prior to the incidents.

During the period between 29<sup>th</sup> May and 10<sup>th</sup> June 2000 three incidents occurred at the Complex. These incidents were subsequently investigated, as required under [COMAH Regulation 19](#), by the Competent Authority and by BP in order to determine the underlying root causes of the incidents and to identify any lessons that needed to be learned.

In addition the Complex Director also immediately set up a BP Task Force to undertake a wider review of all operating units and functions across the Complex and commissioned some external independent investigations and assessments. These were aimed at determining the overall effectiveness of current arrangements at the Complex for health, safety and environmental affairs. The BP Task Force was the largest audit team ever assembled for a petrochemical complex and completed 4 man years of work in 8 weeks.

The power distribution failure (29<sup>th</sup> May), the medium pressure (MP) steam main rupture (7<sup>th</sup> June) and the Fluidised Catalytic Cracker Unit (FCCU) fire (10<sup>th</sup> June) each had the potential to cause fatal injury and environmental impact, although no serious injury occurred, and there was only short term impact on the environment. BP were prosecuted on indictment in Falkirk Sheriff Court on 18<sup>th</sup> January 2002 and pleaded guilty to two charges relating to the FCCU fire and the MP steam main rupture incidents. BP Chemicals Limited were fined £250,000 and BP Oil Grangemouth Refinery Limited were fined £750,000.

This public report into the series of incidents is designed to summarise the incidents and the following investigations carried out by the Competent Authority and by BP. Full details of all the detailed investigative work carried out by the Competent Authority and BP and all the detailed incident specific findings and legal work are not presented here.

The report seeks to reassure the public that a series of thorough and detailed investigations into the causes of the incidents have been carried out by all parties concerned. In addition the report is intended to demonstrate that a number of lessons have been learned both by BP and by the regulators and actions have been taken in order to improve safety performance at the Complex. The report is also intended to be viewed by a wider audience of companies, safety professionals and Trade Union representatives involved in the major accident hazard industries and to serve as a reminder of many of the issues that need to be addressed by safety reports for major hazard installations. Operators of COMAH sites are expected to carefully consider the contents of this report and the HSE will use Trade Association contacts plus site inspection plans and other means to publicise the incidents and to ensure the lessons are widely learned.



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## **Executive summary** **Description of each incident**

### **Power distribution failure - 29<sup>th</sup> May 2000**

On 29<sup>th</sup> May 2000 at 18:07 p.m. all power was lost to No. 1, 5 & 10 electrical substations that supply electrical power to the North Side of the Complex which contains the Oil Refinery, various **chemical plants**, **utility plants** and **logistics facilities**.

As a result, emergency shutdown of the Oil Refinery and the chemical plants on the North Side occurred and the utility plants were also affected due to a loss of power to the main cooling water pump systems. (There was some smoky flaring visible as a result of the emergency shutdown.)

In addition because of the duration of the power failure, a controlled shutdown of some other facilities elsewhere on-site (some chemical plants on the South Side and the Kinneil operations) was also necessary because the supply of steam for the correct operation of the **flare system** could not be maintained.

No injuries resulted

### **MP steam main rupture - 7<sup>th</sup> June 2000**

An 18" medium pressure (MP) steam main located near to the A904 Bo'ness road ruptured at 23:18 p.m. on 7<sup>th</sup> June 2000 resulting in a significant loss of MP steam directly into the atmosphere. The steam leak damaged fencing immediately adjacent to the ruptured pipework. Debris and steam was blown across the road until the leak was isolated. The leak also caused significant noise (similar to a jet engine) being heard in the Grangemouth area. A member of the public walking the dog 300 metres away sustained rib injuries from tripping over the dog.

There was significant disruption to the steam supply system for the Complex for approximately one hour until the steam leak could be isolated and as a result of the incident the A904 Bo'ness road was closed for public access until 22<sup>nd</sup> June whilst repairs were carried out.

### **Fluidised Catalytic Cracker Unit (FCCU) fire - 10<sup>th</sup> June 2000**

The Fluidised Catalytic Cracker Unit situated on the Oil Refinery had been shutdown on 29<sup>th</sup> May 2000 following the power distribution failure. On 10<sup>th</sup> June 2000 at approximately 03:20 a.m. during start up procedures which commenced on 9<sup>th</sup> June there was a significant leak of hydrocarbons from the Fluidised Catalytic Cracker Unit (FCCU or Cat Cracker) creating a vapour cloud which ignited resulting in a serious fire. On and off-site emergency services were mobilised, the **BP Incident Management Team (IMT)** were called in and the **Grangemouth Petrochemicals Complex Major Incident Control Committee (MICC)** was convened. The fire was brought under control in approximately 90 minutes and totally extinguished by 10:30 a.m.

During the fire and in the fire-fighting efforts some damage resulted to asbestos cladding surrounding pipework and vessels. Some hydrocarbons in the contaminated firewater run-off were discharged directly into the River Forth.

No injuries occurred to the workers in the vicinity. They followed the emergency response procedures. However, there was the potential for injury to people and greater damage to equipment.



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## Executive summary

### Competent Authority response

Following the incidents major public and political concern was expressed to the **Competent Authority** and the Competent Authority was concerned due to the frequency and pattern of the serious incidents, their major accident potential and the apparently deteriorating performance of the Complex.

It was apparent that the main concerns centred on health and safety issues so it was agreed at an early stage with the Scottish Environment Protection Agency (SEPA) that the HSE would take the lead in the investigations with assistance from SEPA as necessary. The FCCU fire in particular was a reportable major accident under the COMAH Regulations and a major accident investigation was therefore required.

The HSE Board called for a “**Level 1**” **Major Accident Investigation** to be carried out by Land Division, Hazardous Installations Directorate (HID) in accordance with the then corporate major accident investigation procedures.

A series of incident specific investigations for the power distribution failure, MP steam main rupture and FCCU fire in order to examine the direct and underlying causes were accompanied by a series of further investigations into related issues from the incidents such as the emergency response, the environmental impact and the response to the presence of asbestos during the FCCU fire.

Evidence of the extent of the Competent Authority’s concern is provided by the scale of investigations carried out which involved significant HSE Inspector, HSE Specialist Inspector and Health and Safety Laboratory (HSL) resource as well as involvement from SEPA Inspectors. Investigations continued until February 2001, when the “Summary of Findings and Recommendations Report” was sent to BP and the prosecution report was sent to the Procurator Fiscal (the public prosecutor in Scotland).

Consideration was given by the Competent Authority to carrying out a full-scale audit of the entire Complex of the type the HSE had carried out at [BNFL Sellafield and UKAEA Dounreay](#). The Complex Director set up a BP Task Force to carry out an extensive safety and environmental audit of the Complex led by a senior executive from outside the Complex. The setting up of such a major BP Task Force, which involved independent overview from a respected expert, allied with the thoroughness and open sharing of findings with the Competent Authority eliminated the need for a Competent Authority audit running alongside the major accident investigation. The Competent Authority received regular electronic updates of the current status of audits, actions and tracking of progress from BP. BP reported to the HSE daily any issues that were identified during the 6 week period over which the units in the Complex were brought back into operation.



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## **Executive summary** **Direct and underlying causes**

### **Power distribution failure**

The loss of electrical power was caused by damage to a 33kV underground electricity feeder cable which eventually resulted in an earth leakage (electricity flowing to earth) from the cable. The damage had been caused to the electrical cable during excavation of a trench for the installation of a new cable, sometime before the distribution failure occurred.

The local circuit breaker on the distribution system failed to operate due to the insertion of small plastic connectors which isolated the relay. Two circuit breakers located elsewhere in the distribution system subsequently tripped to clear the fault resulting in the loss of power supply to significant parts of the Complex.

Subsequent investigations revealed a number of weaknesses in the safety management systems on-site over a period of time which contributed to the succession of events that resulted in the power distribution failure.

### **MP steam main rupture**

The site wide power distribution failure on 29<sup>th</sup> May 2000 resulted in excess amounts of water (associated with the shutdown of utility supplies) being sent to drain, as well as the unavailability of electrical power to drainage pumps. This led to the flooding of culverts (service tunnels) beneath the A904 Bo'ness road through the site which contained medium pressure (MP) steam distribution lines. During the following investigations to determine whether the flooding had caused any damage to the pipework a steam trap located in a low point in the section of pipework beneath the road in the West Gemec culvert was closed to allow safe access for inspection. The steam trap was subsequently not re-opened and this prevented the removal of condensate (hot water produced by the condensation of steam) from this section of the system. As the liquid

condensate level built up in the pipework a quantity of steam (or “steam bubble”) was trapped between the hot condensate and closed isolation valves on the southern side of the culvert beneath the road. Eventually collapse of the steam bubble resulted in a phenomenon called “condensation induced water hammer” which led to a gross overpressure and the subsequent catastrophic failure of the pipeline.

Subsequent investigations revealed a number of weaknesses in the safety management systems on-site over a period of time which contributed to the succession of events that resulted in the MP steam main rupture.

### **Fluidised Catalytic Cracker Unit (FCCU) fire**

The Fluidised Catalytic Cracker Unit had been shutdown as a direct consequence of the power distribution failure. During start-up of the unit on 10<sup>th</sup> June there was a leak of hydrocarbons which were subsequently ignited and resulted in a fire on the plant.

Investigations revealed that the leak was as a result of failure of a tee-piece connection at the base of the Debutaniser column which then found a source of ignition nearby (probably an uninsulated hot flange).

During the investigations the tee-piece connection which had originally been installed in the 1950s was found to be correctly specified but incorrectly fitted and then covered in lagging. (A set-on tee-piece had been installed whereas a seamless forged weld reducing tee-piece had been specified.) There had been no subsequent amendment to the plant layout drawings to identify the change.

Prior to the mid 1980's modifications had been made to the pipework at the base of the column and a valve removed which resulted in there being inadequate support for the remaining pipework and the tee-piece connection.

Further modifications to the FCCU in 1996/1998 had resulted in the FCCU being increasingly difficult to operate reliably. This had resulted in an increase in the number of start-up/shutdown cycles for the plant and pipework.

Failure of the tee-piece connection pipework was probably caused by a combination of the incorrectly fitted tee-piece connection, the inadequately supported pipework and the cyclic stresses/vibration caused by the increased start-up/shutdown activity on the plant. Eventually this led to “fatigue” failure of the pipework in the vicinity of the welded connection.

Subsequent investigations revealed a number of weaknesses in the safety management systems on-site over a period of time which contributed to the succession of events that resulted in the FCCU fire.



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## Executive summary Description of each incident

## Findings and recommendations

The investigations carried out by the Competent Authority identified a number of key findings for each of the three incidents. Further investigations into **alarm handling**, the overall **safety management systems** at the Complex, the response to the presence of **asbestos** during the incidents, the overall **environmental impact** of the incidents and the **emergency response** during the incidents were also carried out by the Competent Authority and also identified a number of issues. Key recommendations relating specifically to the circumstances surrounding each of the incidents were made and are included in the main text of this report.

The investigations also identified a number of common themes and a number of wider conclusions were drawn as a result of the investigations relating to the health, safety and environmental management system at Grangemouth. These were:

- **BP Group policies** set high expectations but these were not consistently achieved because of organisational and cultural reasons;
- BP Group and Complex Management did not detect and intervene early enough on deteriorating performance;
- BP failed to achieve the operational control and maintenance of process and systems required by law;
- The **BP Task Force** findings and recommendations properly addressed the way forward to ensure safe and reliable operations at the Complex.

Recommendations were made by the Competent Authority for the BP Grangemouth Complex and for BP Group and these are included in the main text of the report.



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## Executive summary

### Key lessons for industry

The investigations into the circumstances surrounding the three incidents at the Complex have resulted in a number of issues being identified from which BP and the HSE consider lessons can be learned. These lessons are of relevance to all companies who are regulated under the [Control of Major Accident Hazards \(COMAH\) Regulations 1999](#) for major hazard installations and also to a wider audience throughout industry.

These lessons should be addressed by other operators, and management systems put in place to prevent any major accidents (including a repetition of any of the three incidents reported here) from occurring.

The HSE consider that these lessons will assist the major hazards industry in reducing the probability of major accident incidents occurring and in reducing the severity of any events which do subsequently occur. This should help in achieving a significant reduction in the number of reportable incidents. The "[Revitalising Health and Safety](#)" strategy document from the HSE sets a goal to "prevent major incidents with catastrophic consequences occurring in high-hazard industries" and sets a target of "a 20% reduction in [RIDDOR dangerous occurrences](#) and COMAH Regulation 21 major accidents (accidents of sufficient seriousness to require notification to the European Commission)" by 2004. These lessons, if learned, should help to achieve this target which has been set as an industry objective and signed up to by many of the leading companies in the major hazard industries.

### Key lessons for major accident hazard sites

A summary of the key lessons for industry from the series of incidents at Grangemouth is given below.

- Full details of the key lessons- it is recommended that these lessons are read in full.

- **Lesson 1:** Major accident hazards should be actively managed to allow control and reduction of risks. Control of major accident hazards requires a specific focus on process safety management over and above conventional safety management.
- **Lesson 2:** Companies should develop key performance indicators (KPI's) for major hazards and ensure process safety performance is monitored and reported against these parameters.
- **Lesson 3:** Disruption to utility supply systems (steam, electricity etc.) on a major hazard site can cause significant problems and have the potential to result in a major accident.

In addition the Competent Authority considers that it is important to re-iterate some important messages for industry at this stage of the implementation of the "Revitalising Health and Safety Strategy".

- **Full detail of the strategy - it is recommended that these messages are read in full.**
- **Message 1:** Major hazard industries should ensure that the knowledge available from previous incidents both within their own organisation and externally are incorporated into current safety management systems.
- **Message 2:** Operators should give increased focus to major accident prevention into order to ensure serious business risk is controlled and to ensure effective corporate governance.
- **Message 3:** The COMAH safety regime is "living process" and should be used as a management tool to assist in process safety management.