DETECTING AND REDUCING FUGITIVE EMISSIONS
SAVES MONEY

A GOOD PRACTICE CASE STUDY
AT SHELL’S STANLOW ETHYLBENZENE UNIT

This Case Study demonstrates the environmental, health and financial benefits of a fugitive emissions leak detection and reduction (LDAR) programme at a chemical manufacturing plant.

In 1995, Shell adopted an LDAR programme at an ethylbenzene unit at its Stanlow chemical and refining manufacturing complex. The primary aim was to reduce fugitive emissions of volatile organic compounds (VOCs) from leaking valves but financial benefits have also been achieved from reduced solvent use. Since the programme started, fugitive emissions of VOCs have fallen from 116 tonnes/year to just 11 tonnes/year.

The implementation of the LDAR programme at Shell has brought many benefits, including:

- 90% reduction in fugitive emission rates, assisting in meeting VOC emission reduction targets
- Reduced exposure of the workforce to potential health risks and fire hazards
- Reduced solvent cost by over £18 000/year
- Improved environmental awareness of employees
Background

Fugitive emissions of volatile organic compounds (VOCs) from leaking valves can be a problem for many companies using organic solvents. By identifying where leaks are occurring and taking corrective action, companies can reduce the levels of emissions significantly and, at the same time, benefit from cost savings in their solvent use.

In 1995, Shell decided to address this problem at its chemical and refinery manufacturing complex at Stanlow by adopting a fugitive emissions leak detection and reduction (LDAR) programme for valves in its ethyl-benzene unit (EBU). The main aim was to reduce fugitive emissions at the plant, but Shell also wanted to:
- achieve health, safety, environmental and cost benefits;
- increase employee environmental awareness and involvement.

The Approach

The LDAR programme adopted by Shell involves monitoring valve leakage levels periodically using a portable flame-ionisation detector and identifying any valves that exceed a threshold level of 10 000 parts per million by volume (ppmv) when tested (see Fig 1).

Operators tighten or ‘pull up’ the valve gland bolts of these ‘leaker’ valves and then carry out another reading. Those valves still above the threshold are tagged for further repair, which is either carried out on-line or at the next scheduled shutdown when they can be removed for overhaul.

Shell prepared a register of valves in the unit and completed data sheets for all of them. The plant was subdivided into 14 process engineering flow schemes and a register of process valves established for each scheme. This formed the basis of a manageable monitoring schedule. This initial stage involved considerable effort and accounted for a large part of the set-up costs of the programme (see Table 1). Operators use the register to record individual valve detection and on-line maintenance results and to itemise any changes to the plant.

A monitoring and maintenance procedure was developed that:
- specifies the programme methodology;
- schedules each valve for monitoring;
- specifies which operating shift is responsible for carrying out the work;
- is reviewed annually to keep it up to date, and audited.

Operators were trained to use the equipment, record results and repair valves. Communicating the benefits of the programme helped to gain and maintain their commitment to the programme.

Emission rates are updated once a year to determine year-on-year reductions. They are estimated by applying an emission factor relating to the type of plant and service of the valve.

The programme covers only gas and light liquid service valves. Although benzene process lines are the main focus, ethylbenzene, polyethylbenzene and other process valves are also included.

Fig 1 LDAR programme flow sheet

<table>
<thead>
<tr>
<th>LDAR programme initiation</th>
<th>Develop valve inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Routine procedures</strong></td>
<td></td>
</tr>
<tr>
<td>LDAR valve leak detection monitoring</td>
<td>Yes</td>
</tr>
<tr>
<td>Leak detection reading ≥ 10 000 ppmv?</td>
<td>Yes</td>
</tr>
<tr>
<td>On-line valve repair?</td>
<td>No</td>
</tr>
<tr>
<td>Record for off-line repair</td>
<td></td>
</tr>
<tr>
<td>Quality control/Audit checks</td>
<td></td>
</tr>
<tr>
<td>Data management</td>
<td></td>
</tr>
<tr>
<td>Estimate emissions and reductions</td>
<td></td>
</tr>
</tbody>
</table>

Regulatory Requirements

The EBU at Shell’s Stanlow manufacturing complex is regulated under Part I of the Environmental Protection Act 1990, controlled under the Integrated Pollution Control (IPC) authorisation covering petroleum processes. It is also covered by the Control of Substances Hazardous to Health (COSHH) Regulations 1994.

Fugitive VOC emissions do not have to be measured themselves, but IPC authorisation states that continuous improvement is required to minimise emissions from the systems, and that effectiveness of any improvements should be measured. The LDAR programme helps to achieve these objectives.
Valve packing materials

As part of the LDAR programme, Shell has investigated technical improvements in valve performance. For example, Shell made significant progress in selecting and standardising packing materials for the valves. It now uses just two types of packing - a ‘solid graphite ring with braiding’ packing for all new valves and braided packings for existing globe and gate valves. Both of these types of packing have been shown to reduce emissions significantly. The braided packing performs well in used valves where the V-shape can expand and take up tolerances around the packing.

These improvements in valve technology have contributed to fugitive emission reduction and saved Shell money by reducing the number of different packings held in its stores.

Programme Costs and Savings

In addition to reduced VOC emissions, the LDAR programme has led to significant cost benefits through reduction in feedstock losses. By 1998, net annual cost savings of £16 950/year were being achieved against the development, capital and set up costs of the programme of £11 450.

Environmental Benefits

Monitoring results are recorded each year and data on leak detection fed into a central spreadsheet to calculate estimated emissions and reductions in losses since the previous year.

Initially, up to 10% of the valves were identified as leaking and annual emission rates were estimated to be 116 tonnes. This was reduced by 41 tonnes in the first year as a result of leak detection and initial online maintenance.

After three years, annual emission rates had fallen to approximately 11 tonnes - a 90% reduction over the period.

Successful Implementation

Shell’s experience of the LDAR programme has shown that the approach can be transferred readily to other organisations of any size. Even when considering the EBU in isolation, the investment of capital and resources in the programme has been financially attractive. The approach can be adapted easily to the needs of a particular site and hence can be transferred to many other small and medium-sized operations.

Table 1  Benefits of the LDAR programme

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Baseline</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fugitive emissions (tonnes/annum)</td>
<td>116</td>
<td>75</td>
<td>38</td>
<td>11</td>
</tr>
<tr>
<td>Reduction in emissions (tonnes/annum)</td>
<td>41</td>
<td>78</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Programme set up costs</td>
<td>(£)</td>
<td>(£)</td>
<td>(£)</td>
<td>(£)</td>
</tr>
<tr>
<td>Capital costs</td>
<td>8 600</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Commissioning costs</td>
<td>2 850</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total programme set up costs</td>
<td>11 450</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Programme cost savings</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings from emission reductions</td>
<td>7 250</td>
<td>13 750</td>
<td>18 600</td>
<td></td>
</tr>
<tr>
<td>Running costs (monitoring, data management and equipment maintenance)</td>
<td>(1 650)</td>
<td>(1 650)</td>
<td>(1 650)</td>
<td></td>
</tr>
<tr>
<td>Annual net cost savings</td>
<td>5 600</td>
<td>12 100</td>
<td>16 950</td>
<td></td>
</tr>
</tbody>
</table>

ACTION PLAN... to set up an LDAR programme

- Break down the number of plant valves into manageable monitoring schedules.
- Establish a set procedure to ensure valve schedules are up-to-date and incorporate process changes.
- Produce a central spreadsheet to manage the data and calculate the estimated fugitive emissions and reduction in losses over time.
- Adopt lightweight compact monitoring equipment which can be operated by one person.
- Communicate benefits of the programme and raise awareness of health, safety and environmental issues surrounding fugitive emissions.
- Maintain operator training.
Shell’s Stanlow Ethylbenzene Unit
Shell’s manufacturing complex at Stanlow, Cheshire refines approximately 12 million tonnes of crude oil annually, and also has a number of chemical manufacturing processes. The range of products includes petrol, fuel and lubrication oils together with chemical products and intermediates.

The EBU is part of the Cracking Production unit at Stanlow and produces hundreds of tonnes/day of ethylbenzene from benzene and ethylene feedstocks. Ethylbenzene is used in the production of styrene monomer and polystyrene. Around 80 operators and maintenance staff work at the Cracking Production unit.

Comments from Shell Chemicals UK Ltd
The LDAR programme has provided Shell with an improved monitoring and management tool for controlling valve and flange fugitive emissions. Through its implementation, we have been able to reduce process loss, achieve considerable savings and improve health, safety and environmental aspects of operations.

Repeat monitoring with the structured LDAR programme provides information on which types and service of valve are likely to give rise to the highest fugitive emissions.

The support and commitment shown to the LDAR programme has been key to its success. It has made a valuable contribution to enabling the site to meet its objectives for reductions in VOC emissions. Following its success on the EBU, we are now adopting the same approach on other plants.

Mr E T Chandler
Environmental Manager
Shell Chemicals UK Ltd, Stanlow

“It has made a valuable contribution to enabling the site to meet its objectives for reductions in VOC emissions.”

Host Company:
Shell Chemicals UK Ltd,
PO Box 3,
Stanlow,
Ellesmere Port
L65 4HB

Monitoring Company:
Aspinwall and Company Ltd,
Walford Manor,
Baschurch,
Shrewsbury
SY4 2HH
Tel No: 01939 262200
Fax No: 01939 262222
Dr K Anderson