



# VAPOUR RECOVERY SOLUTIONS FROM SGS OIL, GAS AND CHEMICALS

# EXECUTIVE SUMMARY

Whilst the link between man-made emissions and the harmful effects attributed to them are not yet fully understood, there has been increasing concern that action must be taken before irretrievable damage is done to the environment. The need for action is driven by the "Precautionary Principle," defined in the Rio Declaration On Environment & Development as follows:

*"In order to protect the environment, the precautionary approach shall be widely applied by states according to their capabilities. When there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent degradation."*

In other words we should not wait until there is scientific proof that we are damaging the environment, all nations must take whatever action they can whenever there is a serious risk of damage.

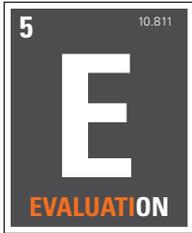
Growing awareness of environmental issues and the concern surrounding air pollution led to a series of international discussions such as the Kyoto Climate Summit held on 10 December 1997 and the Montreal Protocol on Substances that Deplete the Ozone Layer. As we learn more about the damaging effect man's activity is having on the environment it has become increasingly

clear that measures must be taken to reduce emissions of Volatile Organic Compounds (VOCs). In the presence of sunlight, VOCs react with oxides of nitrogen in the air, contributing to the formation of photochemical oxidants such as ozone. In high concentrations ozone adversely affects human health, impairs the growth of vegetation and causes erosion to building materials.

Since ozone generated in one country can be transported long distances across national boundaries, it is only effective if measures to reduce emissions are co-ordinated internationally. Appreciating this, almost every industrialised nation in the world was a signatory to the 1991 Geneva Protocol to the 1979 convention on long range, transboundary air pollution, which committed the European Community to a target reduction of 30% in the annual emissions of man-made VOCs from specific areas by 1999.

One of the specific areas looked at was the evaporation of hydrocarbon vapour during the transportation of petrol from refineries to service stations. It was estimated that in 1988 this activity resulted in 128,000 tonnes of VOC emissions in the United Kingdom alone. Consequently, on 20 December 1994, European Parliament and Council Directive 94/63/EC for "the control of emissions of Volatile Organic Compound (VOC) emissions from storage of motor petrol and its distribution to service stations" was adopted. Member states were required to implement the Directive by the end of 1995 and consequently, in the United Kingdom, the "Petrol Vapour Recovery (Stage 1) (Local Enforcing Authorities) Direction and Notice 1995" came into force in December 1995. The Stage 1 directive is in two parts: Stage 1A, which concerns the control of emissions at petrol Distribution Terminals and Stage 1B, concerning the unloading of petrol product at service stations.





# EMISSION



# LEGISLATION



Stage 1A has demanded substantial capital investment at sites where petrol is stored ready for distribution. This has arisen from the requirement to install, operate and maintain relatively complex equipment to process the vapours which are generated during the storage of petrol and the filling of road tankers. Petrol tanker design and unloading arrangements for petrol at service stations have also been significantly affected as a result of Stage 1B. A statutory limit has now been imposed on the release of petrol vapour into the atmosphere, resulting in the adoption of the "Closed System" of loading/unloading and the introduction of vapour recovery equipment and other emission control measures at all storage and distribution terminals. To allow time for companies and service station owners to adopt the new measures in as cost-effective way as possible, the requirement to comply with Stage 1 legislation was imposed in phases with

virtually all terminals and service station having to comply by January 2005 at the latest.

Local Enforcing Authorities have been given powers in accordance with the Environmental Protection Act 1990 to ensure that all terminals and service stations within their jurisdiction comply with the Stage 1 VOC legislation. Responsible authorities at refinery locations will be HMIP and Local Environmental Health Officers (or SEPA in Scotland) elsewhere. These authorities have been issued with guidance note [PG1/13\(04\)](#) that lays out what techniques are appropriate to meet the aims of the legislation:

## AIMS OF THE STAGE 1 EMISSION LEGISLATION

The "Petrol Vapour Recovery (Stage 1) (Local Enforcing Authorities) Direction and Notice 1995" came into force in December 1995. The aim was to

cut out the systematic venting of VOCs from storage tanks and mobile containers (road tankers and rail cars) and specifically to achieve the following reductions:

### STORAGE INSTALLATIONS

To reduce the total annual loss of petrol resulting from loading and storage at each storage installation to below a target reference value of 0.01% weight by weight of the throughput.

### LOADING AND UNLOADING OF MOBILE CONTAINERS

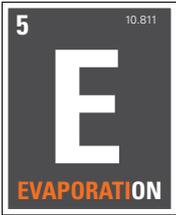
To reduce the total annual loss of petrol resulting from the loading and unloading of mobile containers to below a target reference value of 0.005% weight by weight of the throughput.

### SERVICE STATIONS

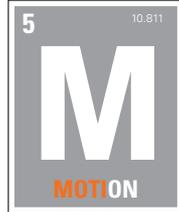
To reduce the total annual loss of petrol resulting from loading into storage installations at service stations to below the target reference value of 0.01% weight by weight of the throughput.

The new legislation specifically sets out to achieve defined objectives of reductions in emissions at each stage of petrol distribution as shown above. This is to be done by employing the best available techniques not entailing excessive cost.

Revisions to the Carriage of Dangerous Goods Regulations, drafted by the HSE for the Department of Transport, will cover changes to road and rail tankers while the requirements for marine loading will be laid down by IMO. Controls on marine loading will apply once any outstanding safety issues have been fully resolved.



# EMISSION



# MONITORING

From 1 January 1999, petrol vapour emissions at distribution terminals must be reduced to below a target value of 0.005% of the liquid throughput. This means a vapour recovery unit must be installed that is able to remove and recover 98% of the petrol vapour generated during the loading of petrol into road tankers.

To ensure the environment is being properly protected the VRU must be regularly tested to demonstrate that the amount of hydrocarbon emitted into the air is below the limit. Roplex Engineering has been carrying out compliance tests for local environmental health officers ever since the legislation was introduced, using very accurate infrared analysers and state-of-the-art data-logging equipment.

## STAGE 1A VAPOUR RECOVERY AT DISTRIBUTION TERMINALS

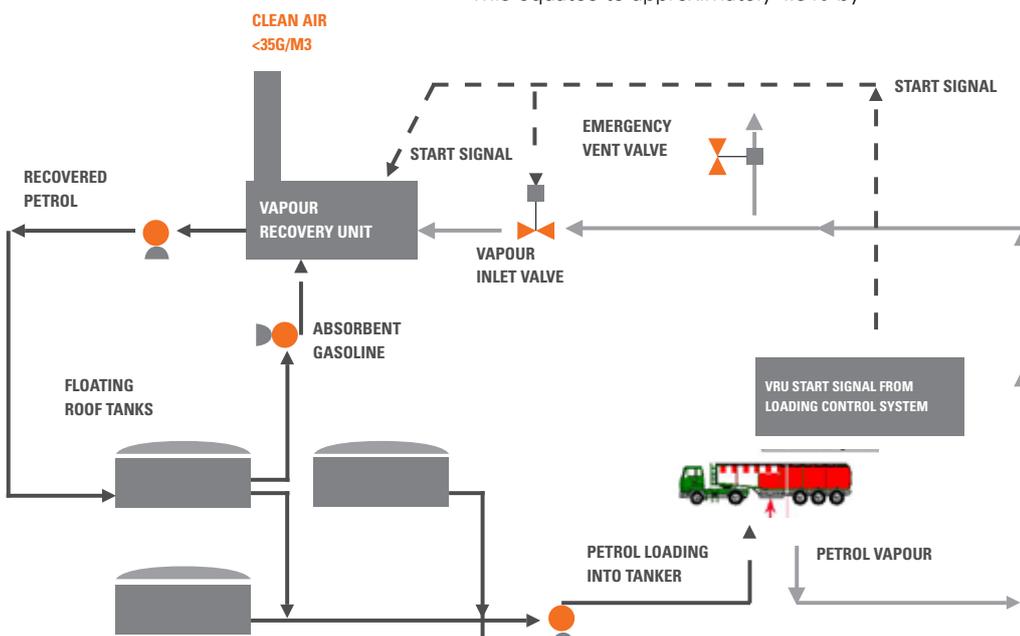
Stage 1A vapour recovery concerns the control and elimination of unwanted emissions of petrol vapour that occur at distribution terminals. Legislation now in force requires that steps are taken to prevent vapour from being released into the atmosphere while loading mobile containers such as road tankers. This can be achieved by adopting the closed system of loading whereby vapour displaced from tankers is returned via a vapour tight connection to a vapour recovery unit (VRU). A signal from the loading bay starts the VRU just before loading commences and the VRU has to be capable of a recovery rate that equals the busiest loading times.

The VRU removes most of the hydrocarbons from the displaced vapours with a target limit for emissions of 0.005% by weight of the petrol loaded. This equates to approximately 1.3% by

volume or 35 grams per cubic metre of air emitted into the atmosphere from the VRU vent. The vapour in the truck could be up to 40% volume concentration (particularly if the tanker is returning from a delivery to a service station equipped with Stage 1B recovery equipment), so the VRU must be almost 100% efficient at recovering the petrol from the vapour.

The most common type of VRU fitted at the majority of terminals in the UK is of the carbon adsorption/absorption design. These rely on the ability of activated carbon to adsorb the many types of hydrocarbon molecules that make up petrol vapour.

At terminals with a throughput less than 25,000 tonnes per year the vapour may be collected in an intermediate storage tank for future disposal. A vapour incineration unit may be fitted at terminals that load petrol onto vessels and where vapour recovery is unsafe or not technically possible.



Typical arrangement of Stage 1A vapour recovery equipment

## STAGE 1B (BALANCED LOADING) AT SERVICE STATIONS

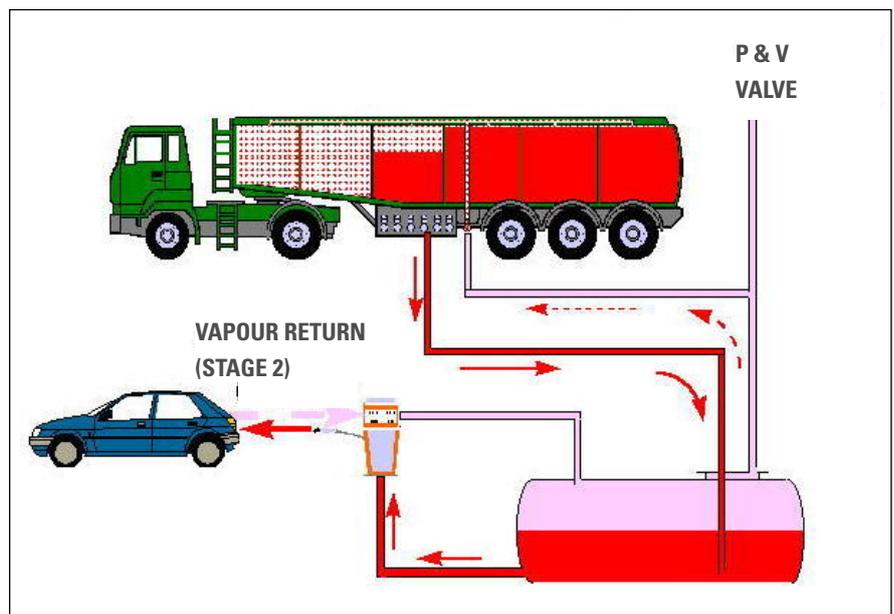
The number of service stations operating with Stage 1B vapour recovery equipment has been steadily increasing over the last few years. According to the latest Retail Marketing Survey published by the Institute of Petroleum, out of a total of 11,423 sites in the UK, 6,504 (57%) have Stage 1B equipment installed. Often referred to as balanced loading, under this method vapour displaced by the delivery of petrol into storage tanks at service stations must be returned through a vapour-tight connecting line to the road tanker delivering the petrol. See diagram below.

Loading operations may not take place unless the arrangements to collect the vapour are in place and properly functioning. The road tanker compartments and storage tank are sealed off from the atmosphere and equipped with safety valves to protect against excess pressure and vacuum. The storage tank relief valve will open to allow air/vapour to escape if pressure exceeds 36mBar and will allow air to enter the tank if the vacuum exceeds 3mBar. The tanker compartments are protected by pressure/vacuum valves that lift at plus 70mBar and minus 20mBar.

As petrol starts to flow under gravity into the service station storage tank, a vacuum is created in the road tanker compartment. This causes vapour to be drawn from the ullage space (the air space above the petrol) in the storage tank into the tanker to replace the petrol that has vacated the compartment.

Also shown in the diagram are the Stage II vapour recovery controls that are designed to capture the majority of the VOCs emitted during vehicle refuelling with petrol at filling stations.

The European Parliament adopted a Directive on Stage II Petrol Vapour Recovery during Refuelling of Passenger Cars at Service Stations on 5 May 2009. The proposal had been agreed by Member States prior to the vote. The new Directive will require the installation of Stage II petrol vapour recovery systems to be fitted to new sites, and those undergoing major refurbishment, with sales of petrol above 0.5 million litres per annum.



It will also require retrofitting of existing stations with an annual throughput above 3 million litres by 31 December 2018.

New sites, and those undergoing major refurbishment, with sales of petrol above 0.1 million litres per annum situated under permanent living quarters or working areas will also have to comply.

The Directive requires that capture efficiency limits be equal to or greater than 85%. Member States are required to comply with this Directive by 1 January 2012.

In addition, the in-service petrol vapour capture efficiency of Stage II petrol vapour recovery systems must be tested at least once per annum either by checking that the vapour/petrol ratio under simulated petrol flow conditions is in conformity with the provisions in the legislation or by any other appropriate methodology.

# CAPACITY

# TESTING

Vapour recovery units have to be carefully designed to meet the customer's specification. The design criteria will be based on the maximum volume of petroleum product loaded into trucks in 15 minutes, 1 hour, 4 hours and 24 hours. A VRU that is undersized will become inefficient, particularly at times when the road tanker loading bays are at their busiest, because it will quickly be overloaded with petrol vapour. Conversely, a VRU that is too large will be more expensive to purchase, much more expensive to operate and will consume more energy (thus creating more greenhouse gas emissions at the power generating station). The supplier will therefore attempt to design the VRU such that it is as small as possible while still meeting efficiency targets under the heaviest demand.

Once bought and installed, how does the customer know that their VRU meets the specification they laid down? In the past this has not been easy since it is impractical to arrange a steady supply of road tankers all with exactly the desired amount and precise concentration of vapour on board simply to test the VRU under maximum load conditions. Apart from this, at the time of purchase the customer may have allowed for some extra capacity over and above the existing throughput in anticipation of some potential future increase in tanker loading.

Using a method developed by a major oil company, Roplex Engineering can accurately test a VRU to its full capacity, usually based on the 4 hour volume of product loaded, by creating a controllable flow of vapour at 40 % Volume into the VRU. This is usually a more demanding test than the emission test required under legislation and provides the customer with confidence that the plant can cope with the heaviest specified loading conditions.



# MAINTENANCE

The Stage 1 directive specifically states that effective preventative maintenance must be employed on all equipment concerned with emission controls. For both environmental and economic reasons it is therefore essential that vapour recovery equipment is maintained at its optimum performance. Process equipment such as this needs regular attention to ensure levels, temperatures and flow rates are within normal ranges and the plant is working correctly. A preventative planned maintenance system should be implemented covering detailed inspections and checked at 3 monthly, 6 monthly and 12 monthly intervals. This maintenance should include testing of critical alarms, functioning of control systems, analysis of seal fluids and carbon samples, and calibration of instruments.

Roplex has been servicing vapour recovery units for more than 20 years. Our early involvement stemmed from the writing of planned maintenance

procedures for new systems being installed around 1988. We were then asked to carry out various modifications to help improve reliability and increase efficiency on a number of units in the UK.

As emission legislation came into effect, VRU manufacturers recognised that customers needed the support of an organisation able to deliver almost instant response and a high level of professional service. They also saw that their own companies, orientated towards design and manufacturing, were not always best placed to offer such after-sales service. Roplex therefore entered into agreements with a number of VRU manufacturers to provide maintenance and support services on their behalf. This meant attending the manufacturer's works to receive intensive training on their equipment and purchasing many thousand pounds worth of specialist tools, programming equipment, software and test gear.

If a problem occurs with a VRU it is important that a repair can be made quickly so that downtime is kept to a minimum. Customers are encouraged to purchase essential spares wherever possible and Roplex stores these in a central spares holding so they can be dispatched to any location needed.

In addition to work on the VRU itself we have been actively involved in procedures to check and improve the efficiency of the vapour collection system, flame arrestors, detonation arrestors, vapour couplings etc.

Of course the extensive testing that we do to confirm compliance with Stage 1 legislation and to facilitate duty reclaim helps us keep an eye on how well the plants are performing. This is fed back into the service department so that improvements can be made where necessary to boost efficiency.



## SUMMARY

The recovery of Volatile Organic Compounds is a pressing issue for all parties concerned.

More so now than ever before, operators' impact on the environment is under scrutiny. By capturing VOCs operators are able to reduce their environmental impact and create a more efficient process by reducing product losses.

## WHY SGS

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