Use of acid at oil and gas exploration and production sites

January 2018

The Environment Agency has received a number of enquiries from the public and partner organisations about a group of techniques, known as acidisation. Acidisation is a common technique carried out to clean and develop wells. It is widely used in the water industry and the oil and gas industry.

Most of the questions we receive regarding acidisation techniques relate to the oil and gas exploration and production sites. Recently the enquiries have been focussed on oil and gas exploration and production sites in the Weald Basin in south-east England. This document covers our responses to the most commonly asked questions relating to these sites.

Important! Please note that these questions and responses only apply to the use of acidisation at conventional oil and gas exploration and production sites.

Environmental Regulation

The Environment Agency takes any environmental risks associated with oil and gas exploration and production very seriously and are committed to ensuring that people and the environment are protected. Oil and gas companies must obtain the necessary environmental permits, unless the activity is exempt from the need of a permit, before carrying out the activities described in this document. Depending on the specific proposals and the local geology the permit may be a standard rules permit or a bespoke permit.

The Environment Agency's regulatory controls are in place to protect people and the environment. If the proposed activity poses an unacceptable risk to the environment it will not be permitted. If for any reason there is a breach of a permit condition or environmental legislation the Environment Agency has a range of enforcement powers available including warnings, notices and prosecution. Any enforcement action is taken in line with the Environment Agency's Enforcement and Sanctions guidance.

What is acidisation in relation to the oil and gas industry?

Acidisation is a term used in the oil and gas industry for different activities using diluted acid. It involves pumping acid into a drilled well or geological formation that is capable of producing oil and/or gas. This is commonly referred to as a target formation. The purpose of acidisation is to clean out the well following drilling and to improve the productivity of the well.

The term acidisation can include acid washes, matrix acidisation and fracture acidisation. Other terms that are frequently used to cover matrix acidisation and fracture acidisation include "acid squeezes" and "stimulation" respectively.

It is important that the Environment Agency have a clear understanding of the type of acidisation activities that are proposed at a site. The information provided is used to make a regulatory decision with respect to whether the activity is acceptable or not, and whether an environmental permit can be granted or whether an exclusion applies.

The use of acid has been, and is still frequently used by the water supply industry to clean out water abstraction wells following drilling. It is also used during the lifetime of water abstraction wells to dissolve scale and fine particles that may have built up over years of use. Scale is actually lime scale that builds up, just as it does in kettles and heating systems.

What type of acids are used?

The type(s) of geology present determines the type(s) of acid necessary to carry out the treatment. The most commonly used acid is hydrochloric acid (HCl). It is usually used at a concentration of 15% or less. It is used to dissolve carbonate rocks, such as limestone or dolomite, or to dissolve calcite cement. Very occasionally hydrofluoric acid (HF) may be required to dissolve quartz or silica based rocks, such as sandstone or clay.

Additional chemicals and fluids may be added to protect the integrity of the well. These include;

- Inhibitors - to prevent the acid damaging the steel casing in the well
- Sequestering agents - to prevent the formation of gels or the precipitation of naturally occurring iron in the well.

How does acidisation work?

The acid, usually hydrochloric acid at 15% concentration (HCL at 15%), is introduced to the particular geological formation in the well. The acid reacts with the alkaline carbonate based rocks and creates a chloride salt solution, carbon dioxide gas and water.

The chemical reaction can be represented by the following formula:

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

Calcium Carbonate **rock** + Hydrochloric **acid** reacts to form Calcium chloride **salt** + **water** + carbon dioxide **gas**

Once acid has been used and has reacted with the rocks, it is referred to as “spent acid”.

When an activity involving acid is carried out on the well the spent acid is circulated back to the surface. Most of the acid is used up during the chemical reaction, as it has reacts with the rocks. If the fluid coming to the surface is still acidic it is neutralised with soda ash. Any carbon dioxide gas produced will be controlled at the site surface, at the well head with valves and pressure release technology. If the well is being used for oil or gas production the spent acid is produced along with the oil, gas and water in the geological formation.

The rate that the hydrochloric acid reacts with the carbonate rocks depends on several factors, including the temperature, the concentration of the acid and the surface area of the carbonate rock available. The type of treatment to be carried out and the permeability of the geological rock formation determines the pressure required for pumping the acid in to the well.

Different types of acidisation

Acid wash

An acid wash is used to clean the well following drilling, or to clean it after a period of use.

During drilling the geological formation(s) nearest to the well bore may become damaged and the natural permeability of the target formation(s) may be reduced by the fine particles created during drilling, along with some of the drilling muds. The fine particles and drilling muds block, or blind, the natural pore spaces in the rock. An acid wash is used to clean the well out following drilling in order to return the natural porosity and permeability of the damaged formation.

When a well has been used for a period of time lime-scale may develop, or small rock particles may accumulate. An acid wash can be used to remove the scale and rock debris to ensure the continued productivity of the well. Plain water or weaker concentrations of acid (usually HCl at 7%) may be used if it is suitable.

The acid is pumped, usually via steel tubing, directly to the area of geological formation that requires cleaning. Only a small volume of dilute acid is applied. The pressures applied to pump the acid in to the well should be enough to counterbalance the down-hole pressure and slightly exceed the formation pressure. The pressure applied allows the acid to move down the well and a short distance in to the formation. This enables the rock and fine particles to be dissolved and is far less than the pressure required to create fractures. It is not the intention to create fractures.

An acid wash activity requires low pressures, and the Environment Agency considers it to be a well treatment, rather than a geological formation treatment. With respect to the protection of the groundwater environment this is considered to be a very low risk activity.

The Environment Agency does not consider an acid wash to be a well stimulation method.

Matrix acidisation

Matrix acidisation involves pumping dilute acid into the oil and / or gas reservoir from the well. The acid is injected, or “squeezed”, in to the geological formation at a pressure that is above the geological formation pressure but below the formation fracturing pressure.

This technique is generally used in higher permeability geological formations. The dilute acid will flow along existing fractures and fissures in the rock. The acid reacts with the geological formation, dissolving the rock, resulting in enlargement of natural pores, fractures and fissures to enhance the permeability of the rock. This increases the productivity of the well.

The Environment Agency does consider matrix acidisation to be a form of stimulation. Matrix acidisation does treat the geological formation, with the aim of stimulating flow in the oil and/ or gas reservoir.

Fracture acidisation / Acid fracturing

Fracture acidisation involves pumping dilute acid into the oil and / or gas reservoir from the well. To enable fracture acidisation the acid is pumped in to the well at pressures above the geological formation fracturing pressure. The purpose of fracture acidisation is to enhance or create new flow paths to the well. Pumping the acid at pressure opens up new fractures and fissures and/or dissolving material in the target formation that is restricting flow to the well. This technique is generally used in lower permeability geological formations.

The acid will not flow readily in to the target formation so is pumped at a higher pressure to force the acid through the existing or induced fractures. The pressure applied, which will be above the geological formation fracturing pressure, enables the rock to be fractured as well as to be dissolved.

The Environment Agency does consider fracture acidisation to be a form of stimulation. Fracture acidisation does treat the geological formation, with the aim of stimulating flow in the oil and/ or gas reservoir. Fracture acidisation may also be referred to as “hydraulic fracturing”.

What is an acid squeeze?

An “acid squeeze” is an oil industry term that is generally used when the intention is for the acid to not travel far from the well in to the geological formation. It is most frequently used when the permeability of the geological formation is very low. An acid squeeze results in the acid being squeezed in to the rock formation and dissolving the rock. It may also result in opening up new fractures, although very

small and close to the well. This may enhance or create new flow paths to enable the well to be more productive. Exactly the same processes are at work as in acid washing, matrix acidisation and fracture acidisation, but just at a very local scale to the well due to the poor permeability of the geological formation.

The Environment Agency assesses each proposed type of acidisation activity on a site specific basis prior to deciding whether the activity is acceptable or not, and whether an environmental permit can be granted or whether an exclusion applies.

Regulation

How do we regulate the use of acids to protect groundwater?

The processes are controlled under the Environmental Permitting (England and Wales) Regulations 2016. To determine the level of control that should be applied to an acidisation process within the oil and gas industry a number of aspects need to be considered before acidisation can proceed.

The type of information the Environment Agency may request can include:

- confirmation of the proposed treatment activity (i.e. an acid wash, matrix acidisation or fracture acidisation or sometimes “acid squeeze”)
- the type, volume, concentration and quantity of acid to be used
- the details of any other chemicals, such as inhibitors or sequestering agents, that are to be used during the activity or chemicals that are used to neutralise any spent fluid that will be returned to the surface (such as soda ash). This requirement includes providing details of the concentrations and quantities of the chemicals to be used.
- how any waste products produced will be disposed of (including appropriate waste coding and checking appropriately licensed sites)
- specification of the well and target formation(s) in which acidisation will be used

When is an environmental permit required?

Not all activities require an environmental permit for a groundwater activity. If an input of a substance is so small as to obviate any present or future danger of deterioration in the quality of the receiving groundwater an environmental permit for a groundwater activity is not required. This exclusion is referred to as “*de minimis*”.

Where discharges or potential discharges to groundwater are involved but any discharge is of a quantity and concentration that is “*de minimis”* no environmental permit for a groundwater activity is required but enough evidence has to be submitted to the Environment Agency to support this.

The use of a “*de minimis*” exclusion can be considered when:

- A discharge to ground of a hazardous substance in such small concentration and/ or quantity that it is self-evident (with minimal investigation) that the resulting input of that substance to groundwater would not cause it to be discernible against the natural background quality or to exceed any relevant minimum reporting value. Such consideration may take into account the possible beneficial effects of the unsaturated zone and the immediate dilution upon entry to the water table.
- A discharge to ground of a non-hazardous pollutant in such small concentration and/ or quantity that it is self-evident (with minimal investigation) that any elevation in concentration caused by the input of that pollutant into groundwater would be environmentally trivial. Such consideration may take into account the possible beneficial effects of the unsaturated zone and the immediate dilution upon entry to the water table.

If the operator is unable to provide sufficient information to demonstrate "*de minimis*" an environmental permit, covering the groundwater activity, will be required.

An acid wash usually does not require a groundwater activity permit if it clearly evident:

- the fluid will not enter the formation and will be re-circulated to the surface; or
- contains pollutants in such small volumes and concentrations that it will not be detected against the background (because, for example, it has been significantly diluted)

Then the activity is likely to meet the criteria for "*de minimis*", and the exclusion under paragraph 3(3)(b) of Schedule 22 to the Environmental Permitting (England and Wales) Regulations 2016 would apply. This is because

- the volumes of acid used in an acid wash are very small,
- the acid will come in to contact with a very small area of the rock in the target formation,
- the acid will react to form an inert salt solution, water and carbon-dioxide,
- the activity is not intended to inject acid a significant distance in to the formation
- there will be no significant residual acid fluid remaining in the target formation after the process

A "*de minimis*" activity is usually considered when the proposed location of the activity is within the oil / gas target formation or production reservoir. In this situation the groundwater may contain naturally high concentrations of hydrocarbons and salts, making any impact from the discharge on the groundwater insignificant or trivial. The fluid is introduced under a controlled pressure so as not to create new fractures in the rock and so that it only penetrates the minimum required distance into the formation.

How do you assess the likely impact of the acid, and other chemicals, on the groundwater environment?

When assessing an environmental permit application the Environment Agency considers the chemicals, the proposed activity and the environmental setting. We consider the conceptual model for the site and then review the proposal to assess whether the inputs of acid, and other chemicals used during acidisation, are likely to have a detrimental impact on the groundwater environment.

Assessments for environmental permits are carried out using the principles of a standard Source – Pathway – Receptor conceptual model and by assessing the linkages between the acid (as a source) and the groundwater (as a receptor).

Assessments to determine whether a site proposal can be considered as a "*de minimis*" exclusion are not detailed assessments but follow the same principles.

The acid and other chemicals

When considering any proposal for acid use we assess the type, concentration and quantity of acid to be used, along with details of any other chemicals (such as inhibitors or sequestering agents), on a site specific basis. We assess each of the chemicals to see if they are considered to be hazardous or non-hazardous, as defined by the Water Framework Directive (2000/60/EC) and the Groundwater Daughter Directive (2006/118/EC). To do this we check the chemical details against the list, or the methodology, provided by Joint Agencies Groundwater Directive Advisory Group (JAGDAG).

The proposed activity

With any proposals received from the oil industry to use acid to:

- clean the well bore following drilling; or
- enhance the productivity of the well by treating the matrix of the rock;

the intention is to use the acid deep below ground within the well or within the target formation. We check whether the proposal is for an acid wash, matrix acidisation or fracture acidisation. As part of this

process we may ask the operator to provide an estimate of how far the acid will move in to the target formation.

The natural geology
We check the predicted natural geological sequence and the predicted characteristics of the rocks at the specific site. For oil and gas exploration or production sites the target formations are deep below ground. We check that the target formation is naturally more permeable than the layers of rocks above and below it and that the permeability of the layers of rocks above and below it provide a natural seal to prevent migration of fluids. This ensures that there is adequate separation between any groundwater in aquifers near the ground surface and the target formation and that the acid will stay in the target formation and not migrate in to other formations.

The well
The well specification will be to a standard to prevent any migration of acid in to other geological formations. If we have any concerns relating to this we would work with the operator and the Health and Safety Executive to investigate. The operator will also provide information on how they will seal the well so that they only use acid in the particular section of the target formation that they wish to work on. This is usually carried out using a piece of equipment called a “packer”. The packers provide a seal in the well above and below the length of target formation that needs to be treated with acid. This prevents the acid migrating up or down the rest of the well.

Treatment of waste arisings.
It is expected that the amount of acid used will be calculated to balance with the amount of rock that needs to be treated, so that the acid will have been used up in the chemical reaction. If the fluid coming to the surface is still acidic and is neutralised with soda ash. We require details of the treatment to be included in a waste management plan, which is submitted with the environmental permit application documents.

What equipment will be on site if acidisation is taking place or proposed?

If acidisation is taking place on a site it will require additional equipment, such as:

- Acid tanks. Hydrochloric acid generally arrives on site at the required treatment concentration. Only very small quantities of hydrofluoric acid may be required and it is generally mixed on site. These tanks are fully contained and bunded.
- Coiled tubing units. Operators often use coiled tubing units to ensure that the acid is delivered to the correct location within the well and is spread evenly along the target area. A coiled tubing unit is a specialised piece of equipment consisting of a reel mounted tubing string. The coiled tubing is run inside the well’s production tubing to the area to be targeted for treatment. The acid is then pumped down the tubing to the target formation.

How do we control and determine if a proposal is acceptable?

The Environment Agency will discuss the initial proposals with the operator, or their consultants, review the technical information submitted in any pre-application documents or in environmental permit application documents. We base our assessment and determination on the information submitted.

We assess what needs to be included within an environmental permit and whether any activities can potentially meet the “*de minimis*” exclusion as defined in paragraph 3(3)(b) of Schedule 22 to the Environmental Permitting (England and Wales) Regulations. We will only issue an environmental permit if we are satisfied the proposed activities meet the requirements of all the relevant legislation.