# Combination of Concentrating Candle Filters and Pressure Plate Filters for Removing Divalent Salts and Contaminants from Monoethylene Glycol (MEG) Reclamation Units

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**Abstract:**
For the transport of Liquefied Natural Gas (LNG) in pipelines, monoethylene glycol (MEG) is added as corrosion inhibitor and to reduce the freezing point of the water in the LNG. The MEG is then reclaimed.

The rich MEG (high water content up to 70% and containing dissolved salts) is run through a MEG reclamation unit and the lean MEG (water content reduced to 10%) is produced by evaporating the majority of the water. The MEG is recycled and reused in the system, leading to an increase of salts concentration during the evaporation process. Although the majority of the salts are monovalent salts as sodium chloride, there are also divalent salts, such as carbonates (calcium, sodium) and hydroxides (magnesium, iron). These salts along with pipeline debris and oxidation products end up in the heat exchangers and jeopardize their performance.

As a solution to the above, the reclamation unit normally contains a pH-adjustment step, allowing the divalent salts to precipitate after adding sodium hydroxide and seeding crystals. The salts and other contaminants can be removed from the rich MEG prior to entering the thermal regeneration section.

This paper discusses the use of a combination system for solid-liquid filtration as an alternative to static thickeners, centrifuges, filter presses and cartridges. In the first stage, the low concentrated slurry is pre-thickened with the use of candle filters to achieve a solids-free filtrate and a concentrated sludge of approximately 4-5 % solids. In the second stage, the sludge is then washed to produce an MEG-free cake for disposal and then dried for non-hazardous disposal.

The paper begins with the bench-top laboratory tests for pressure, filter media, precoat material and similar process parameters. The paper concludes with a case history and installation details including maintenance and reliability.

## Introduction

Typically, MEG is added to natural gas for transportation in pipelines. It absorbs the water contained in the gas and thus lowers the freezing point. At the same time, it serves as a corrosion inhibitor. The glycol is then extracted from the gas in “MEG reclamation units” and regenerated.

Primarily, this involves removal of the previously absorbed water, which is loaded with various salts, depending on the location of the production well. Beyond this, MEG contains oxides and hydroxides due to piping abrasion (i.e. rust particles) as well as other impurities. The resulting deposits clog the heat exchangers, piping and other plant components and lead to high maintenance costs.

Due to increasing environmental awareness and rising operating costs, the treatment and recovery of glycol is gaining importance. The goal of many operations is for the dried solids for disposal to contain no more than ten percent (10%) glycol. Particularly for offshore applications, compact systems are required that operate automatically as well as have low maintenance requirements.

## MEG Regeneration Overview

Initially for MEG regeneration, the divalent salts form a precipitate and the solids are subsequently extracted from the glycol. Depending on the location of the treatment plant, various systems are used for this solid-liquid separation.

For onshore regeneration plants, for example, static thickeners (settling tanks) are often used. They are cost-efficient, but the settled sludge still contains large amounts of glycol. Additional separation systems, for example, such as high-speed separators and decanter centrifuges are subject to considerable wear due to the abrasive properties of the solids.

In offshore MEG regeneration plants, maintenance of separators and centrifuges is a significant cost factor since it is frequent and requires trained specialists. This has often led to the use of backflush or cartridge filters equipped with deep-bed filtration elements. These produce a sludge that contains large amounts of glycol and must, therefore, be processed further. The deep bed filter elements also only have limited self-cleaning properties and require time-consuming disposal. This in turn results in high operating costs as salt content increases.

## Conventional Single-Step Precoat Filtration

Candle filters, as an alternative to separators and centrifuges, have proven to be particularly suitable for both onshore and offshore use. They achieve high-quality filtration, operate fully automatically and are low-maintenance.

A filter cake forms in the filters and subsequently pre-dries. It is then automatically discharged into containers. Since the MEG suspension only contains a small amount of very fine solids, a precoat material, usually perlite, is applied. It ensures a high filtration rate regardless of water quality and operating state. This precoat layer prevents the filter medium from plugging with the fine solids (hydroxides, dust or abrasive particles) and allows the medium to be less impacted by the hydrocarbon constituents in the MEG.

The use of candle filters results in recovering significantly more glycol than conventional separation and has proven reliable under an extremely wide range of operating conditions. The BHS candle filter systems with precoat has been installed for these applications. A typical installation is shown in Figure 1.

While there are benefits to the candle filters with precoat, there are also increased operating costs. The precoat material is delivered in large bags and must be suspended into a precoat slurry tank with water or recirculated filtrate. A typical system operates with three candle filters, divided into 3 x 50 percent. The filters are offset in operation since each filter is precoated and filled anew about every eight to twelve hours.

Use of the precoat material, however, increases the amount of solids for disposal. The precoating also leads to increased costs for handling, storage and disposal costs. While this type of filtration leaves a small amount of glycol in the filter cake, there is a need to further reduce the residual glycol in the cake and reduce the amount of precoat material used.

**New BHS Combination Process**

In order to further reduce the residual amount of glycol and simultaneously offer compact and low-maintenance plants, BHS has developed a new, combination filtration and washing-drying process that does not use precoating or chemicals. It reduces glycol loss by displacing the residual glycol in the filter cake with water BHS lab and pilot-plant testing developed the process and operating parameters.

BHS had installed a combination process with concentrating candle filters followed by pressure plate filters for cake washing and drying for a similar application for the treatment of specialty amines. In this process, the solids in the amine suspension are thickened (concentrated) using candle filters without precoating and then further processed using a plate filter. Figure 2 shows the amine process while Figures 3 and 4 shows the complete BHS skid and process flow for MEG.

Since the suspension contains significantly less than one percent solids, BHS applies the combination process. In the first stage, the suspension is filtered in BHS candle filters without filter aids or chemicals, and pre-thickened. In this approach, similar to the process in settling tanks, a solids concentration is achieved that is capable of being further processed. Depending on the solids content, the batch time, for concentrating, is between two and eight hours.

As soon as a filter cake of a few millimeters has built up through filtration, the suspension feed is stopped and the cake is displaced from the candles. The cake settles for approximately 30 minutes and collects in the cone of the filter vessel. The concentrated slurry that is discharged has a solids content of around three to six percent (3 – 6%) from an initial concentration of less than 1%.

This material is pumped into an agitated vessel. The pre-thickened suspension is then transferred to a BHS pressure plate filter. In the pressure plate filter, the circular plates are arranged in a horizontal plate stack and results in a stable cake for washing and drying of the glycol without the risk of the cake sliding off.

A residual glycol content of less than five percent (5%) is achieved with a low wash ratio. This residual content is lower than by a factor of 30 compared with the conventional filtration-precoating approach. Water consumption can be minimized by using closed-cycle washing or counter-current washing.

After washing, the filter cake is dried by blowing with nitrogen. For cake discharge, the plates are vibrated with 1 HP motors for several minutes. The final product is then crumbly and of low volume. It can be disposed of as a non-hazardous cake as there is only a small trace of glycol and precipitated salts.

## Discussion and Cost-Benefits of the Combination Process

The new BHS combination process provides operators with additional benefits. These include a decrease in operating and maintenance costs as well as improved glycol recovery. A cost analysis is described below.

For an average glycol regeneration process with an hourly capacity of 40 $m^3$, producing suspensions with an average salt content of about 130 ppm, the conventional single-step precoat filtration method requires a filter area of approximately 200 $m^2$ (3 filters each with 65 $m^2$). With a normal cycle time of about eight to twelve hours and a precoat thickness of about 6 to 8 mm, the average consumption of perlite is almost 100 tonnes per year.

By comparison, the BHS combination process requires only three (3) candle filters each with a filter area of 19 $m^2$ as well as only two (2) pressure plate filters each with a filter area of 1 $m^2$. The total area for the BHS combination process is less than 60 $m^2$ compared with 200 $m^2$ for the conventional approach. As shown in Figure 5, the combination design requires only about 70 percent of the investment costs compared with the conventional design.

As for the additional water consumption costs for the cake washing, this is balance out with the savings from the reduced nitrogen consumption for drying. The power requirements for both designs remain at a comparable level. Overall, the ongoing operating costs for the new combination system are only about 20 percent of those for the conventional single-step precoat filtration as shown in Figures 6 and 7. Finally, the new system saves on consumables, requires no chemicals and no filter aid while the loss of MEG is reduced by a factor of 30.

## Summary and Take-Aways

The single-stage precoat filtration using BHS candle filters allows for significantly more glycol to be safely recovered from the natural gas than using conventional methods of separation and centrifugation. The new BHS combination process with concentrating candle filters followed by pressure plate filters for cake washing and drying further increases the glycol recovery efficiency. The combination approach saves on investment costs and operating costs with the elimination of precoating and chemicals as well as is a very compact design saving space for offshore platforms.

The take-away is that process engineers must be creative with their approaches to problem solving and evaluate all filtration possibilities. Laboratory testing and pilot testing is an efficient technique for the determining the optimum filtration solution.

**Figure 1: Conventional Single-Step Precoat Filtration**

**Figure 2: Amine Application Showing BHS Combination of Concentrating Candle Filters and Pressure Plate Filters**

**Figure 3:** **MEG Application Showing BHS Combination of Concentrating Candle Filters and Pressure Plate Filters**

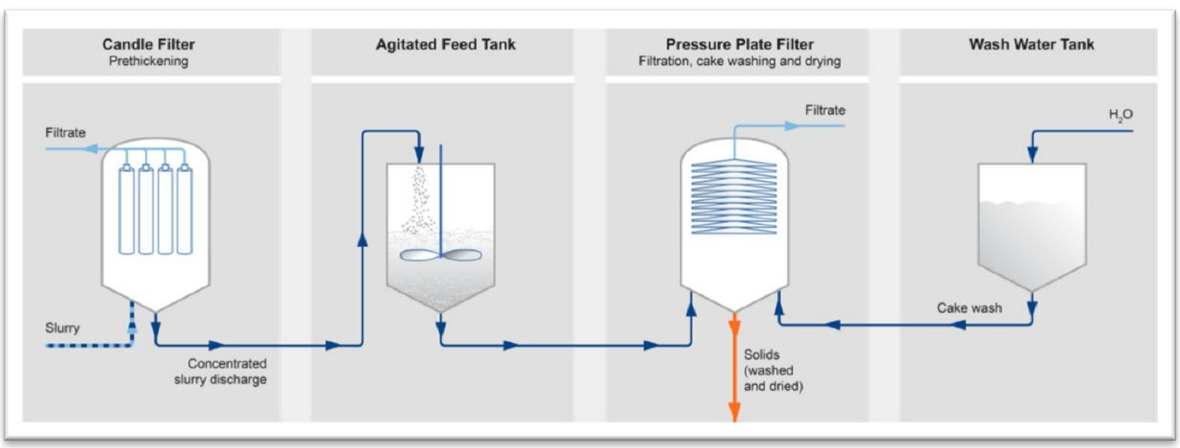


**Figure 4:** **MEG Process Flow for BHS Combination System**

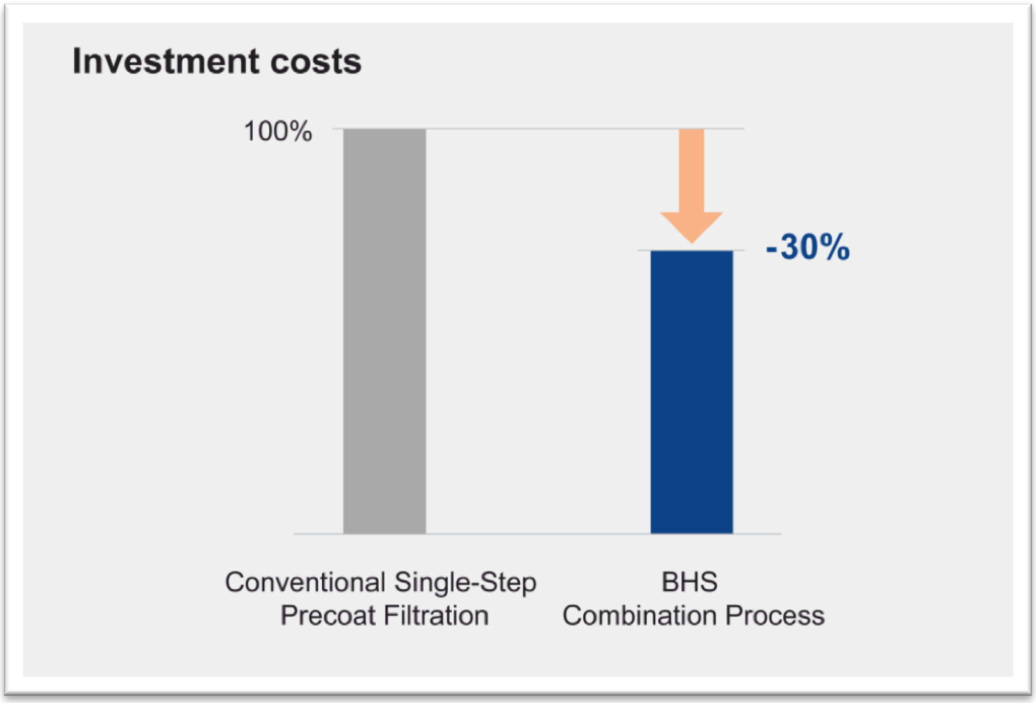


**Figure 5: Summary of Investment Costs**

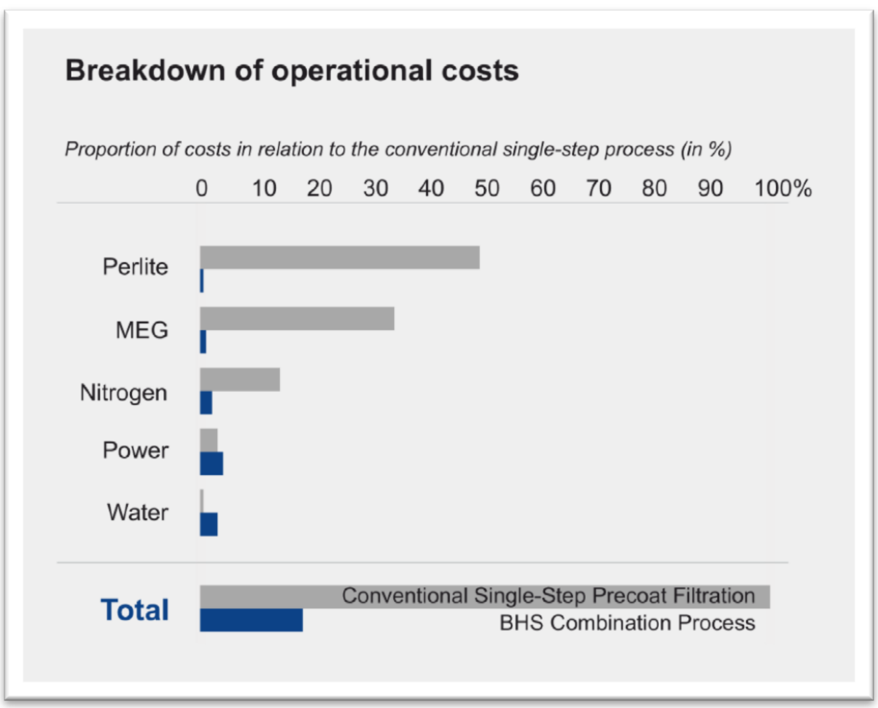


**Figure 6: Operating Costs**

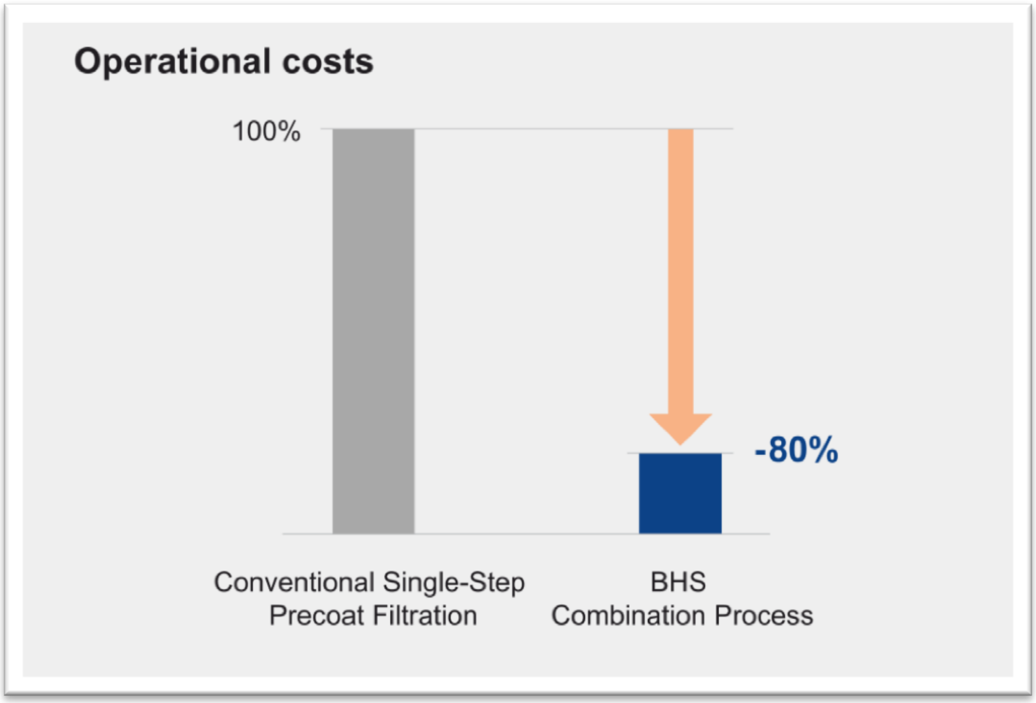


**Figure 7: Summary of Operating Costs**