Food and Beverage


# SUPRApak™ Modules: New Opportunity for Significant Cost Savings in Non-Chill Filtration Whisky Process

**Dr. Carsten Nissen**
*Pall Filtersystems GmbH*
*Planiger Strasse 137*
*D-55543 Bad Kreuznach*

**Ian Norris**
*Pall Ltd. UK*
*Walton Road*
*Portsmouth*

## Introduction

It is the goal of spirit producers around the world to make stable, high quality products that meet customer expectations and deliver good profitability.

During the production of spirits, filtration is one of the most challenging and important steps of the process.

Quality is the main driver of filtration in the spirits industry. However, to select a suitable filter, it is important to consider visual quality while still maintaining the flavor characteristics consumers expect.

Consumers in general, expect a visually clear product in the glass. This refers to most beverages, except for cloudy fruit juices or unfiltered beverages. The explanation for this demand is very simple: regarding human evolution, "turbid" is still associated with spoiled, bad, or inedible. Undesired turbid products can become the reason for customer complaints, and can eventually result in significant losses for the business from product recalls.

The filtered final products therefore must be free from visible particles and should have a clear and bright appearance. However, with spirits the challenge is in the detail.

Spirits are a very fragile and sensitive liquid. Water and alcohol levels in the spirit influence the solubility of turbidity inducing substances making it essential to selectively remove substances which may cause turbidity. On the other side, all quality enhancing substances should remain in the spirit. Fulfilling both is what makes today's spirits filtration a delicate balance. Selective filtration is the magic formula.

## Typical hazes in distilled spirits and selecting the right filter

To better understand the reasons for the use of special types of filters in the distilled spirits industry, typical sources of haze forming components should be examined first.

**Table 1:** Major causes for hazes in distilled spirits. (Klaus Malinowski 2002: Arbeitstagung der Destillateurmeister Nordhausen)

| Reason for hazes | Share in appearing hazes | Haze characteristics | Attribute | Needed filter attribute | Classical used filters |
|---|---|---|---|---|---|
| Crystals (Calcium, Magnesium Silicates) | 25% | Particulate hazes | Amorphous | Surface and depth filtration | Filter sheets<br>Depth filter cartridges<br>Kieselguhr Filtration<br>Cloth filters<br>Bag filters |
| Impurities caused by machinery equipment | 3% | | | | |
| Cork particles | 1% | | | | |
| Iron and copper | 30% | | | | |
| Activated carbon particles | 1% | | | | |
| Microorganisms | 18% | | | | |
| Residues of drugs and plant cells | ? | | | | |
| Essential oils | 1% | Colloidal hazes | Different solubilities in ethanol/water often key aroma precursors | Cooling process necessary for precipitation<br>Removal mainly based on adsorption | Filter sheets<br>Depth filter cartridges |
| Terpenes | 1% | | | | |
| Fusel oils | 1% | | | | |
| Fatty acids and their esters | 13% | | | | |
| Polysaccharides pectin Dextrin | 21% | | | | |

**Essence of Table 1 —**
***2/3 of hazes in spirits are caused by particulate matter, 1/3 caused by colloidal matter.***

The formation of haze resulting from particulates includes crystals, cork particles, abrasion particles from machinery and equipment, iron and copper compounds, activated carbon particles, micro-organisms and cell residues of plant extracts.

These particulate hazes, due to their amorphous structure, can be easily and reliably removed from the spirits by means of different surface and depth filter media, without any quality loss.

Colloidal hazes in spirits are mainly based on fusel oils, terpenes, essential oils, polysaccharides and pectin, as well as the group of higher fatty acids and their esters which are extremely important for flavour and taste characteristics. These substances of colloidal origin are very often responsible for haze formation and are characterized by a different solubility in ethanol and/or water. Removal of fatty acid esters is typically done by filtering at low temperatures (known as chill filtration), as a decrease in temperature causes agglomeration and further precipitation of these components.

Unfortunately, fatty acids and their esters are not only known for their haze origins. They also have a considerable effect on the sensory quality of the spirits. Short chain fatty acid esters such as $C_6$ to $C_{12}$ are major aroma components in all spirits. The fatty acid esters with longer chain lengths, ranging from $C_{14}$ up to $C_{18}$, are in contrast, not only linked to haze, but are also contribute to unwanted flavours in spirits.


| | Chemical Structure | Fatty Acid Ester | Aroma Style |
|---|---|---|---|
| 1 | $C_8H_{16}O_2$ | Ethyl caproate | typical guava aroma, fresh strawberry, apple, banana, pineapple, wine-like |
| 2 | $C_{10}H_{20}O_2$ | Ethyl caprylate | apricot, banana, floral, pear, pineapple, wine-like, fruity |
| 3 | $C_{12}H_{24}O_2$ | Ethyl caprate | apple, banana, pineapple, wine-like |
| 4 | $C_{14}H_{28}O_2$ | Ethyl laurate | mild oily-fatty, green, fruity, floral |
| 5 | $C_{16}H_{32}O_2$ | Ethyl myristate | coconut, soapy, fatty |
| 6 | $C_{18}H_{36}O_2$ | Ethyl palmitate | waxy, fatty |
| 7 | $C_{20}H_{34}O_2$ | Ethyl linolenate | fatty, hay |
| 8 | $C_{20}H_{36}O_2$ | Ethyl linolate | rubber, oily |

UNDESIRABLE CHARACTERISTICS

The purpose of filtration is haze elimination and preservation of desirable aromas which can be a difficult balancing act. It is critical to remove as much as necessary, where haze is concerned, but as little as possible where the quality of the spirit is considered.

For whisky, there are some specific considerations. Not all whiskies have the same lipid levels, and cloudiness does not appear immediately when whisky first drops just below 46%. The length of the hydrophobic carbon tail(s) varies between different lipids, and it is the length of this carbon tail that determines the lipid's solubility in ethanol. Longer carbon tails make lipids less soluble, and these lipids form micelles just below 46% ethanol. Others need the ethanol concentration to drop further. The magical 46% is not a switch that turns cloudiness on and off; it simply marks one end of the micelle forming range as each lipid has its own critical micelle concentration.

Many producers are experimenting with chill haze removal using filtration but without using refrigeration. This is referred to as "Non-Chill Filtration".

There are many non-chill filtered whiskies bottled at 43%. This is low enough for micelle formation to begin, but at this strength the micelle formation may not be visually apparent to the casual observer. Nonetheless, putting one of these whiskies side by side with a chill filtered whisky of similar color often reveals that the 43% non-chill filtered whisky is not as bright, a fact that may not be obvious when it is observed alone. So alcohol strength alone is usually not sufficient to determine whether a whisky is, or is not, chill filtered.

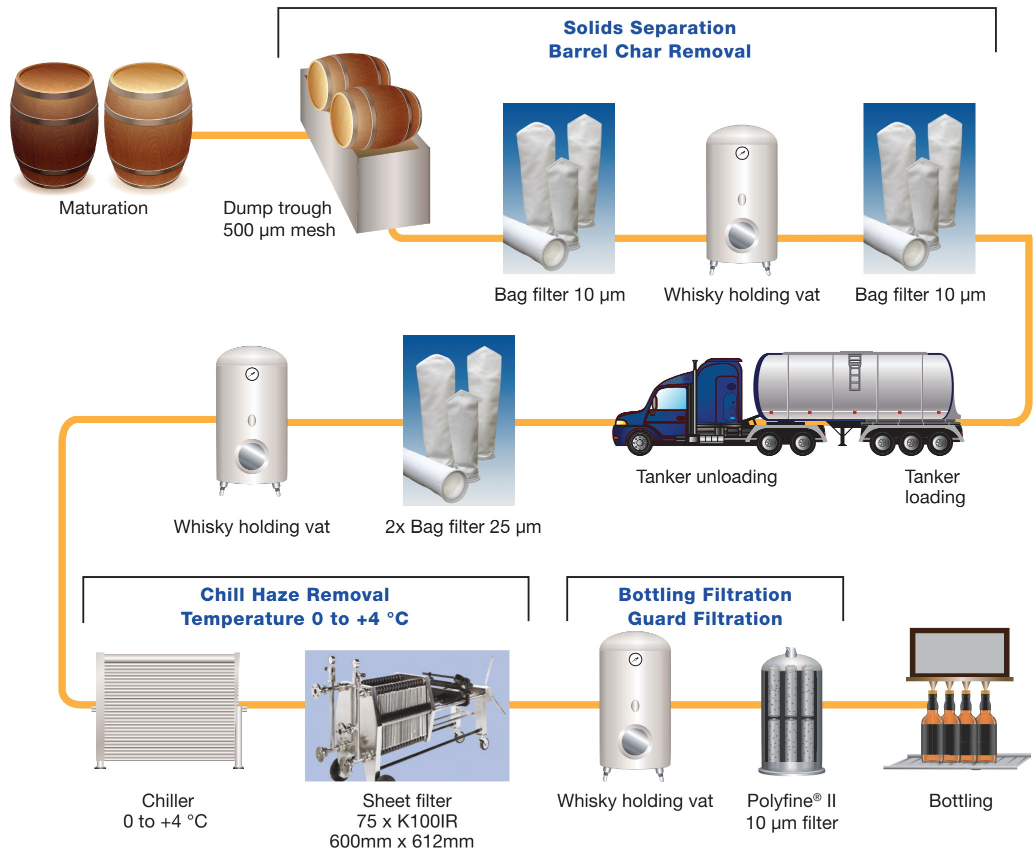
## Problem

For a famous leading whisky producer in Scotland, spirit quality is paramount. The company prides itself in being the leader in the premium malt whisky category as a whisky innovator with numerous awards and accolades across the world for their premium brands.

This producer was repeatedly observing high filtrate turbidity which was out of specification for their process. High filtrate turbidity resulted in line downtime and a reduction in line availability of 0.5%.

Description of former process:

### Chill Filtered Whisky Processing




At the distillery, after maturation, a 500 µm dump trough was used to eliminate barrel char and coarse wooden particles. After the dump trough two 10 µm nominal bag filters were used before tanker loading.

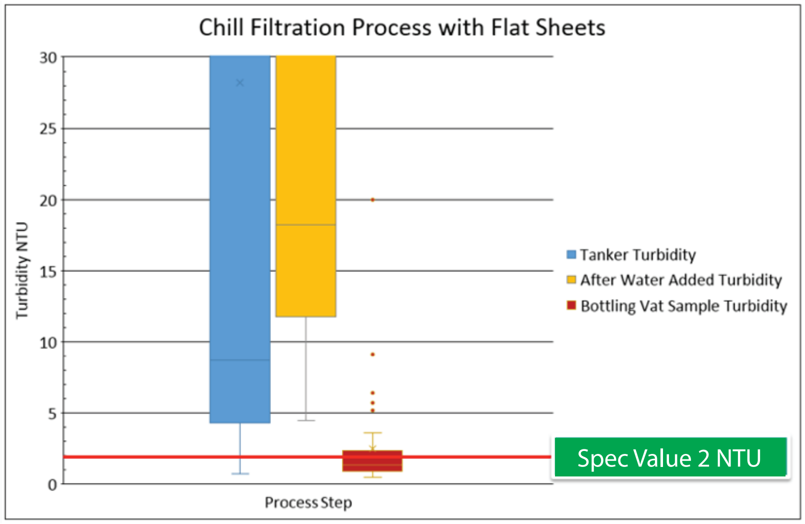
Downstream of the tanker offloading, two nominally rated 25 µm bag filters were used to process the whisky to the holding vat.

The whisky was then processed through the chiller at 0 to 4 °C and filtered through 75 sheets 600 mm x 612 mm to the bottling vat. From the bottling vat the whisky passed 10 µm guard filters prior to bottling.

Data gathered showed a dramatic increase in lost production hours due to the turbidity being out of specification (> 2,0 NTU) for the premium whiskies.

The following boxplot graph show the results of a turbidity analysis of the current process where the current chill filtration process using filter sheets were used.

## Premium Whisky Turbidity Analysis




During the measuring phase, 30% of the bottling vat samples were out of specification with elevated turbidity. The mean turbidity at the bottling vat was 2.5 NTU with out of specification bottling vat samples reaching as high as 20 NTU.

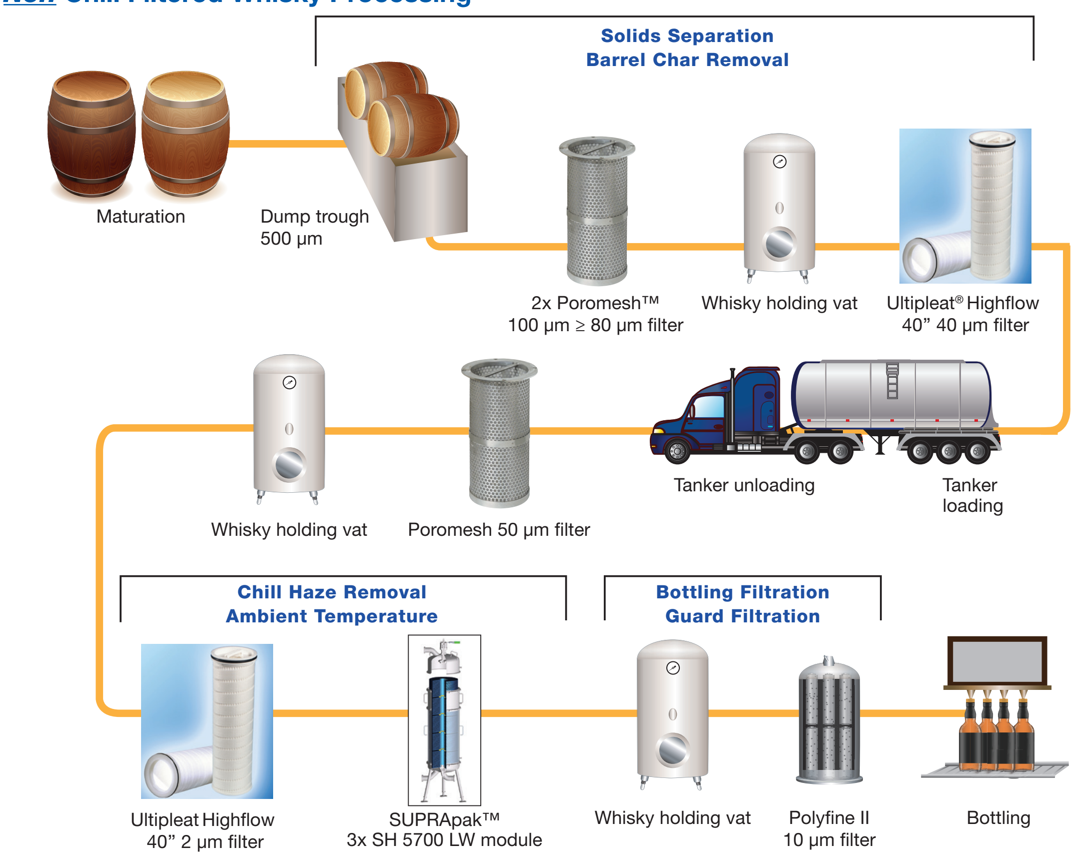
The chill filtration step combined with filter sheets was defined as a major root cause of the current out of spec turbidity.

## Process Improvement:

Based on Pall's extensive reference installations in Scotland, the whisky producer was encouraged to consider Pall's SUPRApak™ filtration technology as a possible solution. With support from Pall, the distiller decided to experiment with a non-chill filtration process using SUPRApak SH modules.

To accommodate the SUPRApak module trail installation, the process was redesigned as follows:

## *Non* Chill Filtered Whisky Processing



After the dump trough, 2 Poromesh stainless steel absolute rated filters (100 µm onto 80 µm), were installed replacing the bag filters. The goal was to increase the dirt holding capacity to reduce production downtime.

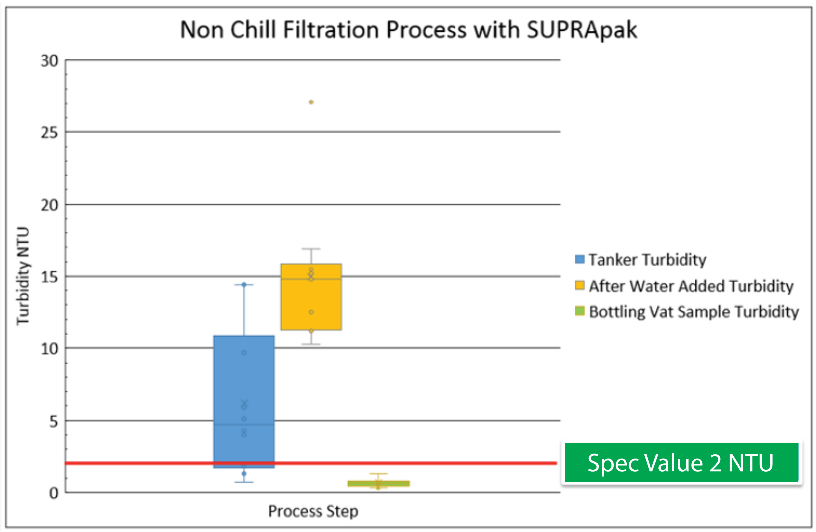
After the holding vat a single Ultipleat High Flow 40 µm filter element was added to ensure the best filtrate quality prior to tanker loading.

At the bottling site, the bag filters were replaced by additional Poromesh 50 µm absolute rated stainless steel filters to avoid any contamination originating from the tanker.

The whisky was then filtered through an Ultipleat High Flow 2 µm 40" cartridge followed by 3 SUPRApak SH 5700 L modules. Filtration took place at ambient temperature at an alcoholic strength of 46% v/v.

Whisky was subsequently filtered into the bottling vat and processed through Polyfine II 10 µm cartridges as guard filters prior to the bottling lines.

The following graph shows the turbidity boxplot when the SUPRApak non-chill filtered process is used.




The turbidity analysis of the non-chill filtration process with SUPRApak filters yielded a mean turbidity of 14.9 NTU of the whisky samples after dilution to 46% v/v alcohol strength prior SUPRApak filtration.

The mean value of turbidity samples taken after SUPRApak filtration at bottling vat was 0.66 NTU.

The maximum bottling vat turbidity was 1.3 NTU which is still well below the defined process maximum specification of 2.0 NTU.

The use of SUPRApak SH modules in combination with a non-chill filtration process considerably improved the turbidity of the bottling vat whisky and also allowed for elimination of the expensive chilling process.

Monitoring of the turbidity values is ongoing to collect more data on the non-chill filtration process with SUPRApak SH modules.

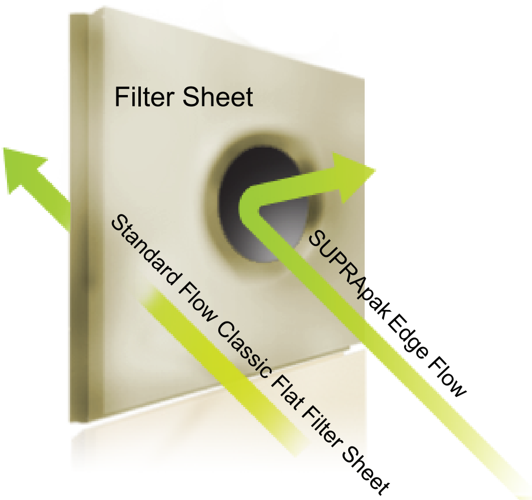
**SUPRApak Edge Flow Technology, the driver of non-chill filtration process**

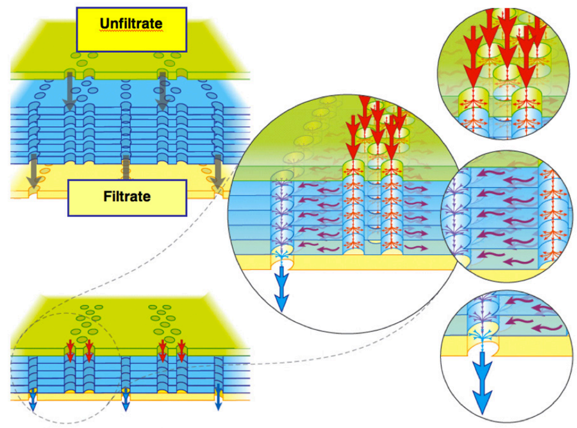
Considering the difference in the turbidity reduction between chill filtration with flat sheets and the non-chill filtration process with SUPRApak modules, the major question is: *What is the difference that allows for filtration at ambient temperatures with SUPRApak modules?*

The major mechanism that drives the removal of chill haze in distilled spirits using sheet media is adsorption. Adsorption is highly influenced by the contact time of the haze colloids with the filter media. Classical sheets used for chill filtration have a thickness of 3.5 to 4.5 mm depending on the type used in the process.

When the spirit is pumped through the filter sheets, it passes the given sheet thickness from the unfiltrate to filtrate side of the filter press and then exits the filter.

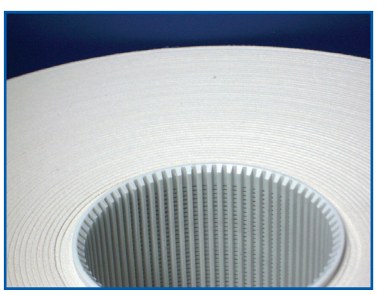
The SUPRApak filter design is an entirely new configuration of filter sheet material, which sets a new standard for enclosed sheet filtration. The modules feature a unique design and flow configuration. High-density packs of filter sheets are rolled around a central permeable core. Fluid travels through the sheet parallel to the sheet surface which results in far better filtration performance than flat sheet filtration, in which fluid travels perpendicular to the sheet surface. This innovative flow pattern called “edge flow” maximizes the adsorptive filtration capability of the sheet media, which enhances removal of chill haze colloids and other haze-causing substances.



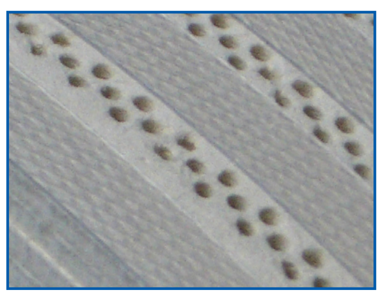

In SUPRApak modules, the filter sheet material contains feed and filtrate channels wrapped around the permeable core (Figure 1) and straps are used to attach the sheet material to the core (Figure 2). This design results in a compact and dense package of high-quality filter sheet material meeting the highest demands for purity and clarity in the filtered product (Figure 3).

Figure 1



Core wrapped in sheet material

Figure 2



Straps and perforated structure of filtrate channels

Figure 3

Core wrapped in sheet material

With “edge flow” technology the distilled spirit has multiple passes through the depth filter sheets which is comparable to the use of multiple flat sheet filter presses in a row. The massive improvement in using the adsorbtive capacity of the depth filter sheet media is key for the non-chill filtration process when SUPRApak modules are used as an alternative to classical flat filter sheets.

## Summary

The installation of SUPRApak SH modules in a premium whisky production process allowed for the removal of refrigeration from the filtration process. This provided economic gains for the producer as energy consumption was reduced. Changing to a non-chill filtration process, in combination with the use of SUPRApak SH modules, also demonstrated consistently lower bottling vat turbidity when compared to the original chill filtration process using flat filter sheets.

The new non-chill process enabled significant reduction in downtime that was previously caused by out-of-specification turbidity. This resulted in increased distillery throughput and overall improvements in production.

In addition, further benefits were realized that helped to reduce production costs throughout the entire process. These included reduced drip losses, improved availability of the filtration process, lower hold up volume and less risk of product taint due to an improved blow out procedure.

Furthermore, employee morale improved. As a side effect of the new filter installation operators are able to maintain a stable shift pattern as they no longer have to rework products.

Pall Corporation

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**Pall Food and Beverage**

25 Harbor Park Drive
Port Washington NY 11050
+1 516 484 3600 telephone
+1 866 905 7255 toll free US

foodandbeverage@pall.com

**Visit us on the Web at www.pall.com/foodandbev**

Pall Corporation has offices and plants throughout the world. For Pall representatives in your area, please go to www.pall.com/contact

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