Process & Packaging, Inc.

Kegs & Keg System Theory & Practice

THE SINGLE VALVE KEG (SVK):

The Single Valve Keg (SVK) or "Sankey" keg, as it is referred to among Craft Brewers, evolved in the United Kingdom in the late 1950?s, driven by the need for a microbially secure draught packaging system for export to Asia.

The SVK system differs from other draught packages in so far as the container and valve (with spear or dispense tube) are a permanently integrated, sealed package. Because of this unique concept, the SVK requires special purpose machinery and equipment for washing, sterilizing, filling and dispensing in order to reap the full benefit of this aseptic, returnable and ecologically friendly package.

To date, the SVK has not reached its full potential in the USA, due to the connotation relating to non-pasteurized draught (draft) beer and the convenience of disposable packaging. However, when the first SVKs, automated machines and flash pasteurization systems were used together in the early 1960?s in the U.K., the concept spread rapidly throughout Europe and the rest of the world as the draught package of choice. In many parts of Europe SVKs still hold more than 70% volume per volume (v/v) of the market share.

SVK BENEFITS:

1. High standards of product stability and control.
2. High in-plant efficiencies.
3. Reduced packaging and operating costs.
4. Improved market image and acceptance.
5. Significant reduction in trade complaints related to product and cooperage.
6. An environmentally acceptable returnable and reusable package.

The SVK and its integral valve and spear tube have evolved over the years into many sizes and varieties. Today's international standard SVK is the 50-liter (13.2 US gallons), stainless steel container. Although sizes around the world range from the 2.5-liter (0.66 US gallons) SVK in Japan to the U.K. barrel SVK holding almost 164-liters (43.3 US gallon). Regardless of the differing SVK sizes and valve styles, they provide a reliable, fully aseptic, returnable container in use almost everywhere in the world.

As the SVKs have evolved, (mostly driven by market needs), so have the machines that wash, sterilize and fill them.

SVK PROCESSING PLANT:

The diversity of SVK processing plant style, size and outputs are considerable, ranging from a single head machine giving an output of 15 SVKs per hour, to multi-head machines with outputs of over 1000 SVKs per hour.

The larger, fully automated systems (given the correct layout), are typically operated by four operators and a supervisor, and require little or no physical effort from the staff. The small semi-automatic systems are equally effective and efficient in terms of simplicity of layout, return on capital and high output to manpower ratio.

Regardless of size and sophistication they all achieve the same objective; they package the product in a condition that is acceptable to the consumer, at a minimum cost to the brewer, while maintaining maximum shelf life.

SVK WASHING:

The washing of SVKs has many variants and is influenced by the valve style in the SVK, the shape of the SVK and the product to be processed.

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SVKs are always washed upside down. When SVK washing is carried out correctly, the wash medium is forced up the inside of the spear tube under regulated pressures and flows to ensure that it cascades over the outer surface of the valve spear tube and down the internal walls of the keg. Experience has shown the ideal flow rates to be 7.5 and 49 LPM (2 and 13 US GPM) respectively. It is important to establish the correct cleaning and rinsing medium (such as caustic and water) film retention thickness, volumes, temperatures and velocities to achieve effective cleaning and rinsing.

There are many variations to SVK washing cycles, however, the following basic process sequence is commonly used in breweries worldwide, for 50 liter (13.2 US gallon) SVKs.:

AIR ASSISTED DE-ULLAGE — Event sequence - To purge the SVK of residual product and CO2 and/or N2.

WARM WATER PRE-RINS — Timed sequence Ambient to 50ºC (122ºF) fresh or recovered water used to rinse out any remaining residual product.

AIR PURGE — Event sequence — To purge the SVK of the rinse water and remaining residual product.

HOT CAUSTIC WASH — Timed sequence - 50º to 70ºC (122 to 160ºF), 2% v/v caustic wash to loosen, breakdown and remove proteinaceous materials from the SVKs inner surfaces.

AIR PURGE — Event sequence To purge the SVK and recover the caustic to a holding tank where it is reheated and titration monitored and adjusted.

HOT WATER RINSE — Timed sequence - 50º to 70ºC (122 to 158ºF), fresh water to remove caustic residuals from the SVKs inner surfaces.

STEAM PURGE — Event sequence - To purge the SVK of the rinse water. This water is commonly recovered to a holding tank where it is then used as the pre-rinse for the next SVK to be washed.

STEAM PRESSURIZATION — Event sequence The steam pressure in the SVK is raised to1.4 BAR (20 PSIG), to achieve a minimum sterilizing temperature of 110ºC (230ºF).

STERILIZE HOLD — Timed sequence The SVK is held at the sterilizing temperature for a pre-set time to achieve complete sterilization of the inner surfaces and valve components of the SVK.

A few points worth noting regarding the aforementioned process sequence, they are:

1. After the air assisted de-ullage purging, the SVK can be pressurized to 2 BAR (30 PSIG) and a pressure loss check carried out to ensure that the SVK valve is not leaking.
2. Caustic soaking time can be added to the sequence where organic materials in the keg are difficult to remove. For example, where SVKs have been air dispensed with picnic pumps and the residual product has oxidized and/or mold colonies have formed in the SVK. Also the high yeasts loading in unfiltered beers such as wheat beer.
3. Depending on the product and the process water hardness, a phosphoric acid wash of 0.2 to 0.4% v/v at 50º to 70ºC (122 to 158ºF), may be employed after the caustic wash. This will help to prevent calcium precipitants and beer stone from building up on the inner surfaces of the SVK.

"Event" sequences are those sequences that are monitored by the SVK washing, sterilizing and filling machine control system, typically a Process Logic Controller (PLC). The PLC receives input signals from, and operates in conjunction with, flow, temperature, pressure and interface sensing devices mounted into the system process pipework adjacent to the process head(s) to which the SVK is connected.

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There is little to be gained from using chemicals and rinse waters at titration levels and temperatures above those detailed. In fact, many of the SVK valve elastomer seal failures and precipitants present in SVKs (such as calcium and beer stone), are due to excessive levels of caustic and high temperatures. These levels are used in an effort to overcome other more serious problems in the washing and sterilizing process and sometimes machine design. More is not always better!

The streaming effect of the condensing steam will generally leave the outside of the spear tube clean and sterile when kegging filtered beers. Washing the outside of the spear tube by reducing the wash flow rate and allowing the wash medium to flow down the outside of the spear tube greatly improves quality when kegging unfiltered beers. There are many variants to washing the outside of the spear tube but this is the most energy efficient.

Equipment suppliers offer many variances of energy and water conservation packages to include:

Recovering pre-rinse water, passing it through a heat exchanger to heat up incoming fresh water and cool down effluent prior to disposal to drain. The effluent can also be used in the rinse section of an External Washer for SVKs prior to disposal to drain.

Recovering the final rinse water and using it for the next SVK pre-rinse.

Recovering the heated cooling water and using it as the final rinse water.

Installing the above conservation systems into an SVK line can reduce the systems water consumption by 50% and the steam water heating consumption by up to 90%.

SVK FILLING:

1. SVKs can be filled in the upright or inverted positions. All automatic kegging systems today fill SVKs in the inverted position. The pros and cons of upright and inverted filling are:
2. Upright filling is slower when introducing beer into the SVK via the spear tube, due to the small cross sectional area of the inner sections of the valve over that of the outer gas valve.
3. Upright filling is more likely to overfill an SVK if some form of accurate metering or filling by weight system is not used. This condition creates a hydraulic pressure in the SVK and can lead to dispensing problems if the hydraulic pressure of the beer is too high when the SVK is first tapped in the bar. This is often one of the causes of the wild beer complaints sometimes experienced by brewers.
4. It is more difficult to hydraulically fill an inverted SVK because the valve spear tube is approximately 5mm (0.2 inches) from the bottom of the SVK. Beer will exit through the spear tube and immediately shut off the beer supply on any automatically controlled filler even without a metering device.
5. Inverted filling through the SVK valve gas port is faster but initially more turbulent than upright filling. Some equipment manufacturers have overcome this problem by introducing various methods of variable flow filling and counter pressure control.
6. The inverted washing and upright filling machines require the SVK to be turned upright between the end of the washing cycle and prior to the commencement of the filling cycle. This method of handling on modern high output systems proves to be cumbersome and inefficient.

A typical preparation and filling sequence for a 50 liter (13.2 US gallons) SVK is as follows:

STEAM STERILIZATION — Timed sequence - The SVK neck and filler connection head are sterilized prior to opening the SVK valve.

STEAM PRESSURE RELIEF — Timed sequence The steam pressure in the SVK is relieved to just above atmospheric pressure.

GAS PURGING — Timed sequence and/or event sequence The SVK is purged of steam and steam condensate with gas and in some instances the volume of condensate is monitored. This can be CO_2, N_2 or a mixture of both.

GAS PRESSURIZATION — Event sequence - The SVK is pressurized with gas to a counter pressurization level that is dependent upon the method and rate of filling used, the beer temperature, and the volume and type of gas or gases in solution in the beer.

FILLING — Event sequence — Filling of the SVK is achieved with a beer "overfill" monitoring system which can be combined with a metering system or a "fill by weight" system at the filling head.

GAS and/or WATER SCAVENGING — Timed sequence - After filling, the SVK valve is closed and the residual beer in the connection head of the machine is disposed to drain or a beer recovery system. The SVK valve and neck are in some instances rinsed with sanitizing water prior to being released from the head.

Special attention to filling techniques, with a view to faster but quieter filling, greater fill accuracy and less product loss is a necessity. Automatic SVK packaging lines include a beer boost pump (a pump between the beer buffer tank and the filler) fitted with a Variable Frequency Drive (VFD) to vary the pump output to match the varying demand of a multi-filling head SVK line. Small automatic and semi-automatic SVK lines will generally suffice with a "flat curve" constant speed pump to achieve the same near constant pressure requirement for good filling conditions.

All automatic and semi-automatic machines are fitted with a sensor in the outlet pipework of the filling head to stop the flow of beer when detected by the sensor. This indicates that the keg has filled correctly or there is a leakage detected across the SVK valve and the filling systems connection head.

Other methods of fill monitoring are generally added (in addition to the outlet sensor), to the filler to comply with "fill" regulatory requirements and product economy. All SVKs are slightly oversized so as to afford headspace expansion in the SVK.

FILLING BY METER:

Beer fill metering used on SVK lines has over the past 36 years fallen into four categories, Turbine, Volumetric, Magnetic Flow and Mass Flow metering.

TURBINE — Turbine meters have a rotor mounted between two bearings. As beer flows past this rotor it rotates. An induction sensor head mounted on the outer wall of the turbine housing senses the rotor blades rotating and produces a series of pulses. When the pulses reach a preset value, the beer valve on the filler and the SVK valve are closed. Turbine meters are accurate to within 60ml. (2.0oz.) but can be susceptible to bearing damage during cleaning and sterilizing regimes.

VOLUMETRIC — The volumetric meter operates on a similar principle but instead of a turbine rotor it uses a rotary piston with three or four accurate volume chambers which have a typical accuracy of ± 100ml. (3.0oz.). The volumetric meter is also susceptible to damage during cleaning and sterilizing regimes.

MAGNETIC — Magnetic flow meters do not suffer similar damage during cleaning and sterilizing since they have no moving parts and measurement is based on Faraday's law of induction. Today's electronics enable high frequency coil excitation and the monitoring of variable flow conditions with greatly improved accuracy and repeatability. Magnetic flow meters are consistently accurate to within 50ml. (1.6oz.).

MASS — The mass flow meter has all the advantages of the magnetic flow meter in so far as there are no moving parts in the flow stream. The mass flow meter measures changes in momentum related to the mass flow rate, the principle is referred to as the Coriolis Effect and has excellent fill repeatability and accuracy but is rarely adopted due to a relatively high cost when compared to the other versions aforementioned.

FILLING BY WEIGHT:

Volumetric filling methods do not (in many countries) meet "fill" regulatory requirements. Therefore, brewers are required to measure the "fill" by weight. This in itself can be difficult when mixed populations of SVKs of varying tare weights are used and the weighing takes place after the filling process.

To address this problem long term development has produced a series of semi-automatic and fully automatic filling machines that use the "Gravfill" system to tare weigh the SVK immediately prior to filling and fill the SVK by weight to within 0.02% repeatability.

QUIET FILLING:

Another filling technique is "Quiet" or "Black" filling.

In this technique, the keg is counter-pressurized to a pressure slightly below the beer supply pressure. As filling commences the gas pressure in the SVK is slowly decreased, until the desired differential pressure is reached.

Although using more gas and taking longer to fill, the technique does overcome problems associated with Nitrogenated beer filling.

Improved SVK valve design and filling techniques have overcome many of the problems faced when filling an SVK, with:

1. Beers at up to 10ºC (50ºF).
2. Nitrogenated beers.
3. High and low carbonated beers using the same filling profile, and;
4. Keeping product losses to a minimum.

AUTOMATION:

As SVK processing plants increase in size, they generally become more automated to reduce labor and physical work, improve efficiency and operator safety.

Today all SVK processing plants and ancillary equipment are controlled by Process Logic Controller's (PLCs) which provide a low cost, reliable and efficient control system.

The more a plant is automated the more it can be integrated into central control areas, interrogated and consequently, its performance monitored.

SVK BEER PROCESSING:

Any live beer spoilage organisms that enter the SVK will affect the desired flavor and color profile if that SVK is not kept at or below 3.5ºC (38ºF) during the time it remains in the warehouse or in the trade. This is the established and most common method used by USA and Canadian brewers, although the wind of change began in 1996 with flash pasteurization becoming a desirable and acceptable alternative in line with the international brewing fraternity.

To take full advantage of the SVKs potential and given that the SVK presented for filling arrives at the filling head under sterile conditions, it is extremely important that the beer does as well. There are two common methods in practice to achieve this, flash pasteurization and sterile filtration.

Flash pasteurized or sterile filtered beer has the advantage of alleviating the need to keep the SVK in a cold environment up to an including dispensing.

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For either system to be effective, it is imperative to adopt a completely integrated process and packaging philosophy. The flash pasteurization or sterile filtration system, SVK packaging line and the SVK must all be treated as a single clean and sterile system to optimize the reduction in spoilage organisms.

Flash pasteurization or sterile filtration is not a solution to poor hygienic practices and to install a flash pasteurizer or sterile filter immediately preceding the filler in an attempt to produce sterile beer under such conditions is doomed to failure.

Flash pasteurization requires the temperature of the beer to be raised and held for a length of time so that the microorganisms are killed. The time-temperature relationship is dependent upon the nature of the product and the organisms to be killed and is normally expressed in terms of Pasteurization Units (PUs). Del Vecchio (1951) defines 1 PU as being a holding time of 1 minute at 60ºC (140ºF).

It is normal for the temperature to be raised to between 70 and 73ºC (158 and 163ºF), and held for 20 to 30 seconds to achieve PU inputs in the range of 9 to 37 PUs..

For more information on flash pasteurization, please refer to the Processing Equipment, Beer Flash Pasteurization - Theory & Practice section of this web site.

Sterile filtration can also achieve microbial stability when fitted after a Diatomaceous Earth (DE) filter, providing the DE filter has reduced the microbial loads to <5 yeast cells and <10 bacteria cells per liter before final sterile filtration.

Sterile filtration tends to be more expensive than flash pasteurization both in terms of cost effectiveness and process robustness. 1997 and 1998 figures obtained from a variety of USA brewers using sterile filtration of varying kinds and depending upon the microbial count, ranged from $1.00 to $2.75 per US barrel (117 liters), compared to flash pasteurization at $0.50 to $0.85 per US barrel.

It is advisable for either system to have a Sterile Beer Tank (SBT) after the flash pasteurization process or sterile filter to afford a stable product and filling control.

When sterility is achieved with filtration, the beer generally suffers some color and protein depletion. This is generally an acceptable product without significant change in flavor.

The flash pasteurization system is considered more complex and requires higher capital investment. It can lead to a flavor profile change if oxygen in excess of 0.05ppm is present in the beer before flash pasteurization, and over pasteurization is not controlled.

The SVK system has come a long way since its introduction and still remains the most efficient, cost-effective method of packaging beer when introduced into the SVK under aseptic conditions. Warehousing and shipping costs are up to 1/5th that of temperature stabilized beer in SVKs, side bung kegs or casks.

With disposable packaging significantly contributing to the USA's 1997 - 217 million tons per year of landfill waste, (source: EPA - Office of Solid Waste). The expansion of the SVK in the North American market has yet to have its day as the package of choice.