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Guidelines for restaurant sous vide cooking safety in British Columbia

July 2017

Prepared by the
Sous Vide Working Group

Endorsed by Chefs and Environmental Health Officers of the Sous Vide Working Group

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Citation: BC Centre for Disease Control Environmental Health Services and the BC Sous Vide Working Group. January 2016. Guidelines for restaurant sous vide cooking safety in British Columbia. Available on-line here. One-page sous vide cooking requirements, available on-line here.

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Special acknowledgement:

we appreciate the advice and review of Dr. Peter O. Snyder www.snyderhaccp.com

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Glossary of Terms

Chef recommendations: in this guideline, the gold standard of Chefs for best practice sous vide cooking are referred to as Chef recommendations.

Cleaning: refers to the removal of soil from equipment, surfaces or utensils. This step precedes the sanitizing step. Effective cleaning will removes oils, proteins and carbohydrates. Cleaning is a multi-step process. (1) visible soil is removed by scraping or rinsing; (2) a cleaning agent such as detergent is applied; (3) a rinse step may be necessary before a sanitizer is used.

Come up time (CUT): this is the period of time it will take for food to reach a specific internal core temperature. This is similar to waiting for a conventional oven to come up and equilibrate to a specific temperature. Settings on the immersion circulator are recommended to be set at least one degree higher than the desired internal core temperature of the food. Once the internal temperature of the food has come up to the desired target, it must be held for another period of time that will be equivalent to a 6.5-$\log_{10}$ to 7-$\log_{10}$ reduction of bacteria to achieve a full pasteurization. The CUT will depend on the size (thickness) of the food, the initial temperature of the food, and the amount of food placed at one time in the equipment. This must be established by the Chef (operator). CUT is also known as the time for foods to reach temperature equilibrium with the water.

Control points: a point in the food flow, from receiving to preparation to customer service where an opportunity exists for achieving optimal food quality and safety. For example, when receiving food items from suppliers, one control point is to ensure refrigerated and frozen foods are received at the appropriate chilled temperatures (either at or below 4°C and –18°C, respectively).

Corrective action: action that is required when a critical limit is not met. Some examples include:

- cooking the product longer
- reheating the product
- discarding the product

Critical Control Point (CCP): a point in the preparation process where a food safety hazard can be controlled. Subsequent steps in the preparation process will not eliminate the hazard if it is not controlled at this point.

Critical Limit (CL): a standard or parameter that must be met to control the food safety hazard at a Critical Control Point. Critical Limits are measurable; examples include:

- final cook temperature of 74°C for 15 seconds
- final cook temperature of 63°C for 4 minutes
- cooling of foods to a storage temperature of 4°C or less within 2 hours
- hot holding temperature of 60°C or more

Equilibrium cooking: a term used by Chefs to describe the point at which the internal temperature of sous vide food in an immersion circulator is at the same temperature as the water in the immersion circulator. This is referred to as equilibrium cooking.

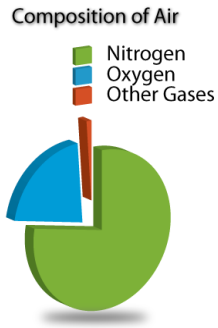
Finishing: refers to steps taken to finish the cooking or appearance of foods immediately prior to service. For example, for sous vide style cooked meats, this may refer to searing to impart the Maillard browning and taste affect, or the addition of spices or sauces. Finishing, as one step in the sous vide process, may either contribute to the calculation of the total log reduction required for pasteurization (cooking) of the food; or, may be the designated critical control point.

Food safety standards: in this guideline, the prescribed or minimum food safety standard is given. These are minimum food safety controls or standards acceptable to Environmental Health Officers, and they are usually based on food codes and health code regulations. Chef recommendations often exceed these standards.

Hazard: from the food safety perspective this is a biological (microbiological), chemical or physical agent capable of causing harm, i.e. foodborne illness.

Log reduction: a log is a mathematical term that is short for logarithm, an exponent of 10. A one-log reduction of bacteria means to eliminate microorganisms by a factor of ten (10). If there were one thousand (1000) micro-organisms, they would be reduced to one hundred (100). Sous vide pasteurization of all foods (except poultry) must achieve a 6.5-$\log_{10}$ reduction; in poultry a 7-$\log_{10}$ reduction is required. This is equivalent to a 99.9999% (6-log) to 99.99999% (7-log) reduction of bacteria in foods.

LT LT: low–temperature long–time food pasteurization, another term often applied to sous vide.



Modified atmosphere packaging (MAP): this refers to the packaging of foods in gas mixtures to improve shelf-life. The gas ratios of oxygen, nitrogen and carbon dioxide (O_2:N_2:CO_2) in different mixes are used for various types of foods. The oxygen content is lower and carbon dioxide content is higher than normal atmospheric air to minimize the growth of spoilage bacteria. Normal air is usually 78% nitrogen, 21% oxygen, 0.3% carbon dioxide with the remainder made up of other gases. MAP for smoked fish, for example, is 60% carbon dioxide, 40% nitrogen and no oxygen.

Pasteurization: the thermal process of heating up food for a predetermined time and temperature to reduce the number of microorganisms and pathogens by a required amount in the food. To achieve a full sous vide pasteurization, the total time food must be held at a specific temperature will be the sum of the CUT ***plus*** the time held at that temperature to reach the log reduction standard. Here is an example for a chicken breast sous vide pasteurized to an internal temperature of 65°C. The chilled sous vide pouch of chicken is added to an immersion circulator set to 67°C, and it takes 25 minutes before the internal temperature of the chicken breast "comes up" to 65°C. The calculation for a 7-log reduction at 65°C is an additional 3.2 min. Therefore the chicken breast should be held for a minimum period of 25 min + 3.2 min = 28.2 minutes to achieve proper pasteurization.

Potentially hazardous food (PHF): any food that consists of milk or milk products, eggs, meat, poultry, fish, shellfish or any other ingredient in a form capable of supporting growth of infectious or toxigenic microorganisms.[2]

Reduced oxygen packaging: this refers to packaging which excludes oxygen. This term is used to describe vacuum-packaged foods, where all air is excluded, and modified atmosphere packaging foods, where some oxygen is excluded.

Rethermalization: is a generic term used to describe the reheating of previously cooked potentially hazardous foods for hot-holding or immediate service. Reheating may take place in a microwave, convection or conduction ovens, hot water baths, etc. The criteria for rethermalization depends on whether the food is hot-held or served immediately, and the number of times the food has been rethermalized and cooled. PHF that are fully cooked, then cooled to 4°C should be: for *hot-holding* rethermalized to 60°C (55°C for SVP foods) and for *immediate service* rethermalized to any temperature provided foods are not in the danger zone for > 2 hours. PHF that are fully cooked, then cooled to 4°C, then rethermalized and cooled again should be: for *hot-holding* and for *immediate service* reheated to 74°C or higher.[2]

Sanitizing: refers to the destruction of bacteria, viruses and other harmful organisms. Surfaces must be cleaned prior to application of a sanitizing process. Heat or chemical methods may be used to achieve this outcome. A specific chemical concentration, contact time and temperature needs to be followed. If surfaces are not properly cleaned, the presence of soil will reduce the effectiveness of the sanitizing process. Prior to sanitizing a common approach is to (1) prerinse, (2) wash, and (3) rinse before (4) sanitizing.

Sous vide: translated from French, this term means to place under vacuum. **Sous vide cooking:** sous vide style cooking refers to a process where vacuum-packaged foods are immersed in a temperature controlled water bath (or steam oven). Sous vide foods are usually cooked at lower temperatures than traditional cooking (less than 80°C or 176°F). These lower temperatures preserve moisture, flavor and colour of foods, and by breaking down proteins, sous vide foods are more tender. In this guideline this term is used when describing vacuum pouched foods that are heated or cooked sous vide style, but the cooking step does not reach a time or temperature sufficient to achieve full pasteurization (i.e. does not allow for full log reduction of bacteria). An initial sous vide cooking step may precede a secondary sous vide cooking step (at another temperature) and/or a final finishing step that when combined results in full thermalization or cooking of the food.

Sous vide pasteurization (SVP): this term describes a sous vide cooking step that does reach the prescribed log reduction of bacteria, 6.5-log reduction for all foods except for poultry, where a 7-log reduction is required. Foods described in this guideline as sous vide pasteurized have achieved thermalization.

Thermalization: cooking of foods to a prescribed log reduction of bacteria, 6.5-log reduction for all foods except for poultry, where a 7-log reduction is required. Thermalization can take many forms, frying in a pan, boiling, microwave etc., including sous vide pasteurization.

Vacuum packaging: this refers to packaging that excludes all gases (air). Foods that are properly vacuum-packaged should not float in water.

Verification procedures: this is a process used to check that a critical limit is met. To check that a cooling critical limit is met, you need to keep track of the time and temperature for the cooling process. The result should be recorded.

EXECUTIVE SUMMARY

Sous vide is a style of cooking under vacuum that allows slower and lower temperature preparation of foods in vacuum sealed bags. It requires very precise control steps and monitoring to minimize food safety hazards. Foods cooked in the sous vide style for service in food premises are acceptable if the following food safety criteria are met:

(1) Recipes and preparation methods must be written out in a food safety plan. Information in the food safety plan must include:
    a. Time and temperature of immersion circulator (or steam convection),
    b. Internal temperature of food, and duration (time) food is held at that internal temperature during sous vide pasteurization,
    c. After food is removed from pouches, and immediately before service to the customer, the internal temperature of food is measured for the recipe. This will account for additional changes in temperature from finishing steps,
    d. Recipes are assessed for temperature/time combinations that provide a minimum bacterial destruction of 6.5-$\log_{10}$ for all sous vide pasteurized foods, except poultry, which requires a 7-$\log_{10}$ reduction of bacteria.

(2) Internal digital probe tip thermometers accurate to ±0.1°C must be used to monitor temperatures. Thermometers should be calibrated, traceable, and certified.

(3) Food grade sous vide pouches (polyethylene, polypropylene) must be used to package foods.

(4) Vacuum packaging machines should be set to deliver enough pressure that sous vide pouches do not float – machines should be able to deliver 90 to 95% pressure.

(5) All sous vide pouched foods stored under refrigeration must be labelled with date, time, discard date and identity.

(6) The minimum acceptable sous vide cooking temperature is 55°C for all meats, except poultry for which the minimum acceptable sous vide cooking temperature is 60°C.

(7) All sous vide pouched foods must be stored in the refrigerator, at temperatures of 3°C and lower (using ice or equivalent). The food safety standard maximum acceptable refrigeration temperature for sous vide packaged foods is 3.3°C.

(8) The maximum storage time for refrigerated raw (un-pasteurized) sous vide pouched food is 2 days.

(9) Sous vide pasteurized foods must be used within 3 days of refrigerated storage. The food safety standard maximum storage time for refrigerated fully pasteurized sous vide pouched food is 7 days.

(10) The optimal cooling rate for sous vide pouched foods after pasteurization is to bring foods to below 3°C within 2 hours using a 50:50 ice water slurry. Food safety standards for cooling rates are to bring foods to below 4°C within 6 hours (2 hours from 60°C to 20°C and 4 hours from 20°C to less than 4°C). Due to the risk of botulinum in vacuum packaged foods, the food safety standard must be further reduced to cool and store at a minimum of 3.3°C.

(11) Seafood sous vide style cooking that does not meet a 6.5-$\log_{10}$ reduction of bacteria requires an additional control of freezing for parasite destruction.

(12) Sous vide cooking below 55°C must not exceed a period of 4 hours. Foods held at temperatures below 55°C for longer than 4 hours must be discarded.

1. General Description of Sous Vide – Under Vacuum

The use of low temperature cooking in the sous vide style as opposed to conventional cooking allows Chefs to control the temperature they cook with thus resulting in more tender meat and fish. Cooking meat at these lower temperatures helps to break down collagen in connective tissue, without heating the meat's proteins high enough that the texture toughens and moisture is lost in the meat.[3] This technique has been described as a low-temperature long-time (LT LT) cooking practice. Meats cooked at LT LT in this way retain their moisture, tenderness, and flavors.[4,5] Meats will also retain their red colour, as the myoglobin is not denatured.[3] Also cooking in this method helps to penetrate the meat with flavors that are added to the bag, such as garlic, shallot or herbs. Vegetables are normally cooked at 85°C for between 1 and 2 hours. This can extend the shelf life of a vegetable up to 10 days without spoiling – although Chef recommendations are to keep sous vide pasteurized foods for up to a maximum of 7 days. Sous vide style cooking can also give vegetables an al dente feel.

Photo courtesy Chef T. MacDonald, VCC

By placing the food in a water bath that is set at the desired final internal cooking temperature of the food, overcooking can be avoided, because the food cannot get hotter than the bath temperature. In conventional high-heat cooking, such as oven roasting or grilling, the food is exposed to heat levels that are much higher than the desired internal cooking temperature; the food must be removed from the high heat prior to its reaching the desired cooking temperature. If the food is removed from the heat too late, overcooking occurs, and if it is removed too early, undercooking results. When cooking sous vide style precise temperature control of the bath and the fact that the bath temperature is the same as the target cooking temperature, allows the Chef to achieve very precise control of cooking. Additionally, temperature, and thus cooking, can be very even throughout the food in sous vide, even with irregularly shaped or very thick items, given enough time at the correct temperature.

Photo courtesy of Chef T. MacDonald, VCC

From a culinary viewpoint the exclusion of air is secondary, but this has practical importance: it allows cooked food to be stored, still sealed and refrigerated, for considerable times. This is especially useful for the catering industry. Sous vide exclusion of oxygen from foods that are susceptible to oxidation, e.g., fat on meat, and that require long cooking times prevent development of rancidity that occurs with long exposures to air. Prolonged cooking of eggs in the shell at low temperatures, for example, is usually included in the category of sous vide, although no vacuum is involved.

One limitation of sous vide cooking is that the desirable Maillard browning reaction does not occur at these lower temperatures. Browning requires much higher temperatures (above the boiling point of

water) to develop. The flavors and "crust" texture that is generally seen as very desirable in the cooking of certain types of meat, such as a steak, cannot be obtained with only the sous vide technique. In some cases, meats and other foods prepared with the sous vide technique will be browned either before or after being placed in the water bath. This secondary browning is done briefly, and sometimes at higher heat than normally used, so as to affect only the surface of the food and to avoid overcooking the interior.

Cooking times can vary considerably. A thin cut of fish may cook in a short period of time, in only a few minutes. Some otherwise tough cuts of meat, for example beef brisket and short ribs, benefit greatly from very long (48 to 72 hours) sous vide heating at medium-rare temperatures of around 55°C (131 F). You can also braise tougher meats like duck leg or lamb shank at 82°C for 8 hours or at 75°C for 12 hours. Cooking the meats in this way also helps to keep the color of the meat.

Sous vide pouched beef (upper) and after browning (lower)

Photo courtesy of Chef T. MacDonald, VCC

A great benefit for Chefs is to be able to have something cook overnight without the fear of it being forgotten or overcooked. This is possible when cooking sous vide style, because the low temperature is maintained throughout the cooking time.

Food can also be used during service situations by using a water bath to heat up a previously cooked piece of protein, then transferred to a hot pan to caramelize and send for immediate service. You can also have portions of fish for example, previously cured, then vacuum packed with a touch of oil and dropped into a 55°C water bath for approximately 8 minutes, and use that as a classic salmon confit.

Restaurant kitchens can choose from several options when serving sous vide prepared foods. Recipes may be designed to cook individual orders that are served immediately – described as a “cook-serve”, or in the case of sous vide, sous vide pasteurized (SVP) and serve “cook (SVP)-serve”. Before service, the SVP food may have a finishing step (such as searing) after the SVP step. Or, grill marks may be added to the food before it is packaged for sous vide. Describing the food flow process is an important part of the overall food safety plan expected by your Health Authority.

WE RECOMMEND A CIRCULATING WATER BATH FOR BETTER TEMPERATURE CONTROL AND A PROBE TIP THERMOMETER THAT MEASURES TO 0.1°C

Equipment and packaging materials used for sous vide

The equipment needed for sous vide is straight forward and includes a temperature controlled water bath or steam oven, a probe-tip thermometer, a vacuum sealer and water impermeable heat stable plastic pouches. The cost and quality of these items vary. Chefs and Environmental Health Officers (EHOs) recommend purchasing a circulating water bath for better temperature control, a probe tip thermometer capable of measuring to 0.1°C, a vacuum sealer capable of maintaining 90 to 95% pressure that is ONLY used for sealing raw foods and food-grade plastic pouches designed for sous vide.

Microbiological hazards in sous vide foods

Food safety hazards are generally categorized as physical, chemical and microbiological. In sous vide foods, the hazard category of most concern is microbiological.

TO CONTROL FOR CLOSTRIDIUM PERFRINGENS GROWTH THE MINIMUM ACCEPTABLE SOUS VIDE PASTEURIZATION TEMPERATURE IS 55°C

Microbiological hazards are made up of bacteria, viruses and parasites that are normally present on food (for example, *Salmonella* on raw poultry is an example of a bacterial hazard). A bacterial hazard can also be introduced into the food through poor food handling practices. For example, *Staphylococcus aureus,* a common inhabitant of nasal cavities' or *Escherichia coli (E.coli)*, a gut microbe, can be introduced into food if food handlers do not practice good hand washing before handling foods. Bacteria thrive in warm temperatures, moist environments, when they have a source of food, and in the right oxygen conditions. Bacteria have the ability to multiply rapidly under the right conditions, and if the conditions stay optimal, the bacteria will divide over and over again. For e.g., *E. coli* can double every 12 minutes – this form of the bacteria is called "vegetative", and this type of growth is considered the most active, or "log phase". Most bacteria like *E. coli* can be eliminated from food by cooking at an elevated temperature for a specific time period. However, some types of bacteria are able to survive the cooking process by forming into spores. Spores are resistant to heat and drying. Like a plant seed, when the spore form of bacteria is exposed to moisture, food, and an optimal temperature and environment, it will germinate and begin to grow again. If the growth is great enough, some types of bacteria can also produce toxins that contaminate food. Many bacterial toxins cannot be removed or destroyed by later cooking, because they are heat-stable.

CHEFS RECOMMEND TO COOL SOUS VIDE PASTEURIZED FOODS IN A 50:50 ICE WATER BATH TO BELOW 3°C WITHIN 2 HOURS

Chicken breasts cooled in ice to 1.5°C

Photo courtesy of Chef T. MacDonald, VCC

The bacteria of most concern for sous vide are the ones that do form spores, and can multiply in warm conditions or in the absence of oxygen, i.e., in vacuum-packaged foods. These include *Clostridium botulinum,* which grows between 3.3°C and 45°C in vacuum-packaged foods; *Bacillus cereus* and *Clostridium perfringens,* which grow between 4°C and 52.3°C.[6] Control points for these and other bacteria are shown in Table 1. Bacteria that do not form spores that are also of concern and can tolerate low oxygen conditions (termed facultative anaerobes) include *Salmonella* spp., pathogenic strains of *E. coli, Staphylococcus aureus, Yersinia enterocolitica, Listeria* spp., and in seafoods, *Vibrio* spp. Two of these bacteria can also tolerate cold environments, these are *Listeria* spp. and *Yersinia enterocolitica* which can grow at temperatures as low as –1.5°C.[6]

Parasites in food may occur naturally, like anasakids or *Diphyllobothrium* worms in fresh fish, or *Trichinella* in wild game meat such as bear. Viruses, like norovirus, may be introduced through unsanitary handling of foods. Parasites and viruses are also eliminated from food through heating. Parasites, in seafoods intended to be served raw, can be

eliminated by pre-freezing food at a specific temperature and time. Viruses and bacteria are not eliminated by freezing. Viruses can also be more difficult to remove using heat, as they may take a higher and longer heating period to destroy.

During the sous vide process, bacterial hazards are assumed to be present at the various process steps. One purpose of describing these bacterial hazards is to identify the critical control points (CCPs) during sous vide style cooking that reduce or eliminate these hazards. Examples of some types of bacterial hazards, the control points, and CCPs for them are shown in Table 1.

Table 1 – Bacterial hazards, control points, and CCPs for the process steps in sous vide style cooking

Sous vide process step	Bacterial hazards	Control points and CCPs
Raw ingredients	Dependant on ingredient Poultry: *Salmonella, Campylobacter* Beef: *E.coli* O157:H7, *Yersinia* Seafood: *Vibrio, Listeria monocytogenes*	Reduce or limit by • Approved source (distributor) • Refrigeration • Good quality ingredients
Reduced oxygen packaging (ROP) vacuum sealing of foods	When proper vacuum is established most spoilage organisms do not grow, these cause off-odours, sliminess, affect taste BUT Pathogens such as *Clostridium botulinum, Clostridium perfringens, Listeria monocytogenes* are of concern	Reduce or limit spoilage bacteria by • Proper vacuum Reduce or limit pathogens by • **CCP:** Refrigeration (on ice; MUST BE below 3.3°C to control *C. botulinum)*
If ROP (vac-pack) foods are not cooked right away	All types of bacterial hazards normally present on foods, pathogens and some spoilage organisms	Reduce or limit by • **CCP:** Refrigeration (on ice; MUST BE below 3.3°C to control *C. botulinum)*
Cooking step	Bacteria in "vegetative" form are killed by heat. Spore forming bacteria remain. These include: *Bacillus cereus, Clostridium botulinum, Clostridium perfringens*	Reduce or limit by • **CCP**: Time and temperature combinations should allow for minimum 6.5-$\log_{10}$ reduction of bacteria
Cooking step & Hot-holding of foods	Spore forming bacteria may germinate and grow if temperatures are not hot enough. *Bacillus cereus, Clostridium botulinum, Clostridium perfringens*	Reduce or limit by • **CCP:** Hold foods at minimum temperatures of 55°C
Chill step	Spore forming bacteria may germinate and grow if temperatures are not cold enough. *Bacillus cereus, Clostridium botulinum, Clostridium perfringens*	Reduce or limit by • **CCP:** Rapidly chill product down to refrigeration temperatures (on ice; MUST BE below <3.3°C to control *C. botulinum*)

FOR BOTULISM CONTROL, VAC-PACK FOODS MUST BE HELD AT 3.3°C OR LOWER. CHEFS RECOMMEND TO CHILL ON ICE TO BELOW 3°C IN 2 HOURS

The heating step in sous vide is best described as a mild heat pasteurization, not a traditional cooking style. If the heating step is not long enough or hot enough to pasteurize and kill all the vegetative bacteria, then temperature control becomes important to reduce the chance of these bacteria growing up to numbers high enough to cause illness. During sous vide style cooking, full pasteurization will kill most vegetative bacteria but the bacterial spores are not destroyed. For this reason, foods not served immediately, must be rapidly chilled to prevent bacterial growth. The minimum regulatory requirement and food safety standard is to cool foods from 60°C to below 4°C within 6 hours, however most sous vide Chefs recommend using an ice water bath to cool foods within 2 hours to below 3°C.[7,8]

Temperature and time controls are required at all steps during the sous vide process, and these include

1) cooling foods before and after vacuum packaging before sous vide heating,
2) temperature and time control for raw sous vide pouched foods under refrigeration before sous vide cooking,
3) during sous vide cooking – confirm the intended internal temperature is reached and is held long enough for full pasteurization,
4) cooling foods after sous vide pasteurization,
5) warming sous vide pasteurized foods for immediate service,
6) reheating sous vide pasteurized foods for hot-holding,
7) finishing of sous vide cooked foods so they are fully pasteurized (thermalized) before service.

Reduced oxygen packaging and microbial hazards. Properly vacuum packaged foods are hermetically sealed so that a vacuum exists inside the package. Absence of oxygen in the packaging will eliminate the growth of aerobic bacteria because these kinds of bacteria require oxygen to survive. Most spoilage bacteria that cause off odours and off tastes are aerobic bacteria. There are however, harmful bacteria that can survive in the absence of oxygen, called anaerobes, the most important being *Clostridium.* In foods, *C. botulinum* and *C. perfringens* are of concern. Both of these bacteria are spore-formers; *C. botulinum* is capable of producing toxins in foods that are deadly: one teaspoon is enough to kill 100,000 people.[9] Bacteria capable of causing foodborne illness and surviving in anaerobic environments include *Bacillus cereus* (another spore-former and toxin producer), *Listeria, Salmonella,* harmful *E. coli* bacteria and others.

Vacuum-packaged foods have caused outbreaks of botulism in the past. Six outbreaks were recorded between 1960 and 1991 in temperature abused foods.[10] The strains of botulism of concern are psychotrophic, meaning they are able to grow and produce toxin at temperatures of less than 10°C. To control for botulism, vacuum-packaged foods must be held below 3.3°C. After sous vide pasteurization, if sous vide foods are refrigerated, holding temperatures are still required to be less than 3.3°C, as spores of *C. botulinum* could still be present and viable. While there are exceptions based on achieving certain levels of pH, water activity, salt levels and cooking lethality, it is unlikely that the process for most restaurant sous vide recipes would meet these criteria.[10]

Microbial hazards if a proper vacuum IS NOT achieved: If proper vacuum is not established, this can change the hazard profile, and affect efficiency of food pasteurization. When oxygen remains in the package, other types of bacteria can survive and multiply – for example, spoilage bacteria. Many spoilage bacteria do grow at refrigeration temperatures, so foods that are packaged, but not processed

right away are vulnerable to spoilage. As mentioned, poor vacuum packaging can also affect the efficiency of the cooking step because air is not removed from the food and package. Heat transfer through liquid contact is better than through air, in fact 23X better.[11] Improper vacuum packaging combined with a sous vide heating step that is for a short duration and low temperature may result in vegetative bacteria surviving.

Chemical hazards in sous vide foods

Plastic packaging is used to vacuum package sous vide foods, and concerns have been raised about migration of compounds from the plastics to the food during the long pasteurization periods. Plastics contain low molecular weight monomers and oligomers and may contain various additives, such as slip additives or lubricants.[12] The migration of such substances into foods are regulated by the European Commission as "Overall Migration Limits" (OML).[12] Packaging that claims compliance with EC Directive 2002/72/EC meets the OML and does not contain unauthorized additives.[12] Food grade plastic packaging is usually made from polyethylene or polypropylene. However, some research suggests that estrogenic chemicals other than bisphenol-A may be present in commonly used plastics.[13] A recent study investigating a variety of plastics found polyethylene terephthalate (PET) commonly used for water bottle manufacture, did not contain detectable levels of estrogen, although low levels of estrogen was found in two out of 18 polypropylene and polyethylene

SOUS VIDE FOOD GRADE POUCHES MADE FROM POLYPROPYLENE OR POLYETHYLENE ARE LOWER RISK

Chicken in 2.0 mil polypropylene sous vide pouches

Photo courtesy of Chef T. MacDonald, VCC

As sous vide process temperatures are low, migrations of chemicals are not as severe as would be expected for boil-in-bag foods. Further studies suggest less than 10% of polyethylene and polypropylene plastics, held at 60°C for 10 days, have estrogen migration, these products can therefore be considered low risk (pers. communication, Dr. Kirchnaway, Mar 29, 2014). Until further research can be conducted into this area, and without further regulatory insights into chemical risks, our recommendation is to use approved food grade materials specifically designed for sous vide applications, and source bags made of polyethylene or polypropylene. Avoid the use of composite plastic materials, as these had the highest levels of estrogens leaching.[14]

Temperatures safety zones for sous vide style cooking

The temperatures used in sous vide style cooking are well below sterilization temperatures, which occur above >121°C (250°F). Sous vide temperature safety zones are described in Figure 1. This diagram and interpretation is adapted from a blog site about sous vide at http://www.sousvidecooking.org/is-sous-vide-cooking-safe/.[15]

Figure 1 – Sous vide temperature safety zones

This site also recommends that raw food not be stored for more than two days before pasteurization, be cooled below 3°C (37°F) within two hours, and that pasteurized food should be served immediately or stored below 3°C (37°F), consistent with Chef recommendations. [15]

2. Time and temperature requirements for safe cooking of foods

Sous vide pasteurization of foods are done at lower than normal conventional cooking temperatures, and are sometimes, but not always, cooked for longer periods than conventional foods. This creates a challenge for the regulator when interpreting recipes for food safety, and for the Chef, when trying to balance consumer preferences for taste, texture and doneness to food safety concerns.

Traditional cooking temperatures will quote a specific temperature for a specific time – for example, cook a chicken breast to an internal temperature of 74°C for a minimum of 15 seconds. The times and temperatures given in food codes and regulations do not address some of the low temperatures encountered during sous vide processes in restaurants. Existing conventional cooking practices are summarized in Table 2.

SOUS VIDE PASTEURIZATION IS ACHIEVED WHEN THE INTERNAL FOOD CORE TEMPERATURE IS HELD LONG ENOUGH TO ACHIEVE A 6.5-LOG BACTERIAL REDUCTION

What are the equivalent cooking conditions for safety of sous vide pasteurized foods? Time and temperature criteria are based on reducing the amount of bacteria in foods. In general, reducing bacterial loads by 6.5 logs is acceptable for most pasteurized foods, with the exception of poultry, where reduction of *Salmonella* by 7 logs is required.[16,17] A 6-log reduction in bacteria, or 6 log lethality, can be translated into a 99.9999% decrease in bacteria. It has also been suggested that a 3-log reduction in bacteria in foods is adequate as long as it is not intended for service to at risk populations (young, old, pregnant, immunocompromised).[18] Consumer advisory is recommended for foods in this category.

We are recommending a minimum 6.5-$\log_{10}$ reduction equivalency for all pasteurized foods except poultry, which will require a minimum 7-$\log_{10}$ reduction, and this is consistent with US and Canadian regulatory bodies.[17,19-21] What does this mean in terms of time and temperature requirements? Numerical calculations exist to inform how long the internal core temperature of the foods will be required to be held at specific temperatures. A table of internal holding times is shown in Table 3. However, only the Chef (or operator) can know how long it will take the equipment and sous vide pouched food to "come up" to that temperature. This time is known as the "come-up time" or CUT, and it is equally important to factor this into how long foods must be held at that temperature to achieve the correct core temperature.[17] By Chefs, this state is also described as equilibrium cooking, and is known as the amount of time it takes the food in the immersion circulator to come to, or equilibrate with water.[22] *This is the point when the food is at the same temperature as the water.*

Guidance based on the thickness of food for how long foods should be held at a specific temperature is given by Baldwin (2012) to achieve a 6.0-$\log_{10}$ reduction.[23] We advise that Chefs measure and record both times separately – the time it takes to achieve equilibrium (CUT) plus the time required for tenderization (pasteurization).

If that time is longer than the time for pasteurization shown in Table 3, then the food safety objective (reducing pathogens to an acceptable level) and the food quality objective (tenderizing food) are both met. If the time is not long enough we recommend the Chef keep the food in the immersion circulator long enough to achieve both objectives: tenderization and pasteurization. The benefit of cooking sous vide style is that foods will not be overcooked, and although times appear long to achieve proper pasteurization, foods will not be overdone or lose their colour, texture, flavour or appearance.

Table 2 – Time and temperature criteria for conventional cooking practices

Code or Regulation	Time and temperature criteria
US FDA Food Code (2013) [20]	Conventional cooking (3-401.11 (A)) (1) 63°C (145°F) for 15 sec (for e.g., raw eggs, fish, meat, commercially raised game meat) (2) 68°C (155°F) for 15 sec (for e.g., injected and comminuted meats, ratites) (3) 74°C (165°F) for 15 sec (for e.g., poultry, stuffed meats, wild game, baluts) Equivalent roasting temperature holding times (3-401.11 (B)) These range in time and temperature from 54.4°C (130°F) for 112 min to 70°C (158°F) (instantaneous)
Canadian Food Inspection System Implementation Group (2004) [2]	Control for raw animal food (Appendix B) (1) 74°C (165°F) for at least 10 min (for food mixtures of poultry, stuffing, eggs, meat) (2) 70°C (158°F) for whole cuts pork, beef, ground meat (3) 63°C (145°F) for 3 min for rare roast beef (4) 85°C (185°F) for 15 sec for poultry (5) 63°C (145°F) for 15 sec for eggs (6) 70°C (158°F) for fish
Canadian Food Inspection Agency (2013) [19]	Tables based on USDA document "Draft Compliance Guidelines for Ready-to-Eat Meat and Poultry Products". These range in time and temperature from Table A – meat not containing poultry – for 6.5D lethality 54.4°C (130°F) for 112 min to 70°C (158°F) (instantaneous) Table B – chicken from 1 to 12% fat content for 7D lethality 58°C for 63.3 min (1% fat) to 73°C for <10 sec (12% fat) Table C – turkey from 1% to 12% fat for 7D lethality 57.8°C for 54 min (1% fat) to 73.9°C for <10 sec (12% fat)
Food Safety Inspection Service (1999)[21]	The times and temperatures listed in this document list internal temperature holding times for 6.5D lethality (the same as what is listed in the US FDA Food Code, above), and 7.0D lethality for *Salmonella* species. These are also the source temperatures for the CFIA standards (above).

Table 3 – Internal temperature holding times for meats and poultry for *Salmonella* destruction

Properly prepared sous vide foods are first equilibrated to a specific temperature (CUT), then held at that temperature for a specific amount of time. Probe tip thermometers used to measure foods should be placed into the centre of the food at the foods thickest part.

Temperature to equilibrate and hold foods for sous vide heating		Amount of time to hold foods to achieve full sous vide pasteurization	
Degrees Centigrade (°C)	Degrees Fahrenheit (°F)	Meats[a, 21] 6.5-$\log_{10}$ lethality	Poultry[b, 24] 7.0-$\log_{10}$ lethality
54.4	130	112 min	Sous vide cooking below 60°C is not recommended
55.0	131	89	
55.6	132	71	
56.1	133	56	
56.7	134	45	
57.2	135	36	
57.8	136	28	
58.4	137	23	
58.9	138	18	
59.5	139	15	
60.0	140	12	16.9 min
60.6	141	9	15.4
61.1	142	8	13.9
61.7	143	6	12.4
62.2	144	5	10.8
62.8	145	4	9.3
63.3	146	169 sec	7.8
63.9	147	134	6.3
64.4	148	107	4.7
65.0	149	85	3.2
65.6	150	67	1.7
66.1	151	54	1.5
66.7	152	43	1.4
67.2	153	34	1.2
67.8	154	27	1.1
68.3	155	22	54 sec
68.9	156	17	48
69.4	157	14	42
70.0	158	0	30
70.6	159	0	24
71.1	160	0	12

[a]Food Safety Inspection Service (1999). Appendix A. Compliance Guidelines For Meeting Lethality Performance Standards For Certain Meat And Poultry Products. Available from: http://www.fsis.usda.gov/OPPDE/rdad/FRPubs/95-033F/95-033F_Appendix_A.htm[21]

[b]Sindelar, JJ, Glass, KA, & Hanson, RD (2013). Developing Validated Time-Temperature Thermal Processing Guidelines for Ready-To-Eat Deli Meat and Poultry Products. (34 p): American Meat Institute Foundation. Available from: http://www.amif.org/wp-content/uploads/10-304.pdf[24]

Food codes and regulations

In Canada, guidance for retail and restaurant food safety is provided by the Canadian Retail Food Services Code (FRFS), and guidance for industry food safety by the Canadian Food Inspection Agency.[2,19] However, neither of these documents provide advice on the sous vide process for restaurant service. In the US very specific criteria for cooking sous vide style is found in the food code, and in Australia general guidance for a safe approach to cooking sous vide style is recommended; these guidelines recommend following the times and temperatures set out by Baldwin, 2011.[11,20,25] A summary of the US and Australian guidance for sous vide foods is shown in Table 4.

Table 4 – Sous vide control guidance from government authorities

	US FDA Food Code (2013) [20]	NSW Food Authority (2012) [25]
Requirements for cook chill sous vide	3-502.12D (1) A HACCP plan per 8-201.14 (2) Foods are (a) consumed on premises (or if off-site within same company); (b) cooked as described in 3-401.11 A or B; (c) protected from contamination; (d) placed in oxygen barrier bags before cooking (or after cooking before temperature goes below 57°C (135°F); (e) cooled to 5°C (41°F) in package, 2 hrs 57°C to 21°C and within 6 hrs from 57°C to 5°C. Storage: (i) cooled to 1°C within 48 hrs, 30 days storage; (ii) cooled to 5°C for 7 days storage; (iii) frozen with no shelf life restriction (f) held in electronically monitored refrigerator checked twice daily; (g) off-site time and temperature monitoring; (h) labelled with product name and date packaged (3) Maintain records (4) Training program	Risks associated with sous vide will be reduced if: (1) thinner portions of food are prepared so that heating and cooling are rapid. (2) water bath temperatures of at least 55°C are used so that the growth of *Clostridium perfringens* is first prevented and then destruction of the cells commences. (3) the time food is held below 54.5°C during cooking is limited to six hours. (4) commercial equipment with adequate heating capacity and excellent temperature control is used. (5) water and/or food temperatures are checked using a tip sensitive digital thermometer that is accurate to 0.1°C. (6) prepared foods are not stored for extended times unless processes have been validated. (7) risks are not compounded. Cooking large portions of mechanically tenderised meat for extended times at low temperatures would be irresponsible.
Consumer advisory	Disclosure and reminder using “brochures, deli case or menu advisories, label statements, table tents, placards, or other effective means”	If you choose to include on your menu foods that remain essentially raw they should only be served following a request by an informed, healthy adult who willingly accepts the risks associated with raw foods

Relationship between time and temperature during sous vide pasteurization

Water is an effective heat conductor. Foods pasteurized in low temperature water baths undergo a gradual increase in temperature until they approach the temperature of the water medium (the set temperature of the water circulator). This allows for precise controlled heating that will break down muscle fibres resulting in tender and flavorful foods. [3,11] Increases in temperature follow a mathematical relationship, and as the internal food temperature approaches the water temperature, temperature increases in the food slow and level off. If you chart out the temperature, you will see a curve that resembles a sigmoidal curve: the most rapid temperature changes occur in the middle, and then plateau as the food reaches the set temperature of the immersion circulator. In low temperature short time pasteurization processes the food may not reach the target (water) temperature, i.e. equilibrium cooking has not been achieved.

Here is an example temperature profile for sous vide chicken breasts placed in an immersion circulator at 66°C for 23 minutes. This data represents a composite for 30 chicken breasts each weighing ~190 g that were individually cooked sous vide style. The average final internal temperature of the chicken breasts at 23 minutes (1380 seconds) was 60°C, not 66°C.[26] The chicken breasts did not reach the equilibrium cooking stage, nor were they held at a specified time-temperature condition required for pasteurization (the length of time for hold at temperature cooking). Finishing was required to achieve pathogen reduction by thermalization.

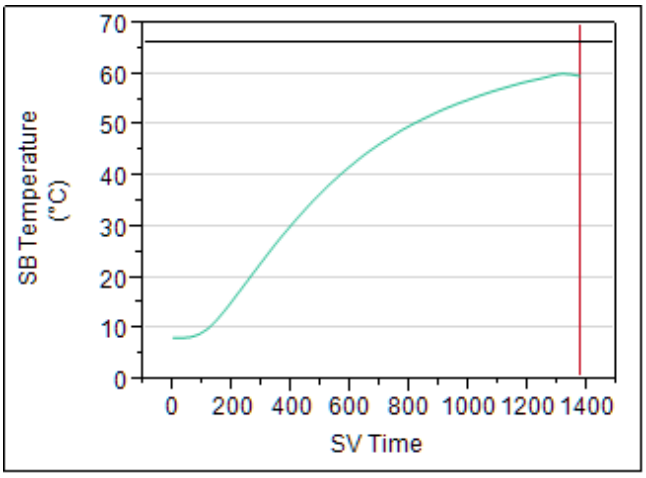


Figure 2 – Temperature profile of chicken breasts cooked sous vide style for 23 min at 66°C

Thickness and shape of the food will affect the time required for food to reach the desired temperature. Thinner portions of foods will come up to temperature faster than thicker portions of the same weight of food. Time and temperature combinations for varying thicknesses of foods between 5 and 70 mm at varying sous vide pasteurization temperatures of 55°C to 66°C can be used as a starting point when trialing recipes, following Baldwin (2012).[23] Fat content and moisture of the food will also affect heat transfer.[19] Chefs must measure time and temperature to achieve either pasteurization during sous vide, or, thermalization during finishing of sous vide style food recipes. When establishing the process for a recipe, it is important to recognize there may be variability dependent on the food and sous vide conditions. It is advisable to take several measurements for foods within a desired size, shape or weight range. We recommend a conservative time and temperature using the maximum (not minimum) time required to achieve pasteurization or thermalization. This will provide a margin of safety for the verification of product temperature and ensure that the sous vide process is reproducible.

Our recommendations for determining time and temperature criteria for safe sous vide style cooking

Preparation of foods cooked in the sous vide style occur in several different flows or pathways in a restaurant setting. The most common of these paths are illustrated in a food flow chart in the next figure. Foods may undergo some preparation before sous vide (being placed under vacuum) such as grilling, marinating, etc.

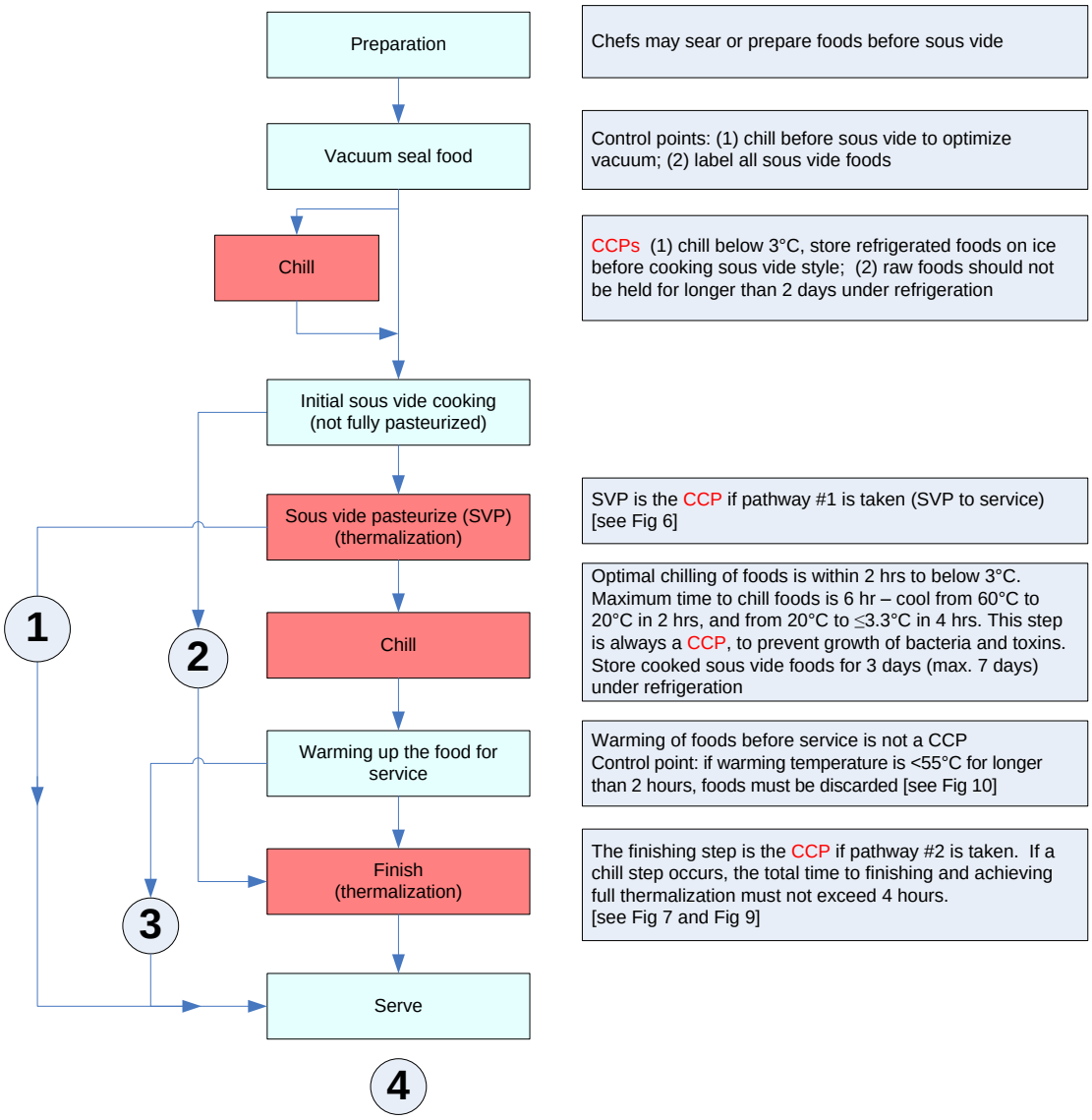


Figure 3 – Overview of sous vide process pathways

The first pathway in the figure shows foods that are sous vide pasteurized and immediately served (path ①, known as cook-serve) – in this pathway, the CCP is the sous vide pasteurization step. Foods may begin with an initial sous vide cooking step (not fully pasteurized), then get finished (e.g., searing) to achieve full pasteurization or thermalization before service (path②, also known as cook-serve), or, foods may be sous vide pasteurized, refrigerated and then later warmed for service with or without a finishing step (paths ③, ④, known as cook-chill-serve). Other methods (not shown in this diagram) include an

alternate method to sous vide water bath/immersion circulation called steam oven pasteurization. In steam oven pasteurization foods are vacuum sealed and chilled after the sous vide pasteurization step.

Time and temperature control of these process steps are required. When validating a recipe for safety, Chefs should measure the internal temperature of the sous vide food using a needle type probe-tip thermometer at each of the process steps for their recipe. Why is this important? A safe temperature not achieved during the sous vide cooking process step may be achieved during the finishing step. This determination can only be made by actually testing the temperature and times held.

To determine time and temperature safety of a sous vide recipe follow these steps:

1. Determine the sous vide process used
2. Measure the internal temperature of the food at each step of the process using a probe-tip thermometer
3. Record the time and temperature of foods for CCPs
4. Determine the final internal temperature of the food before service to the customer

To determine the temperature critical control point (CCP) the first step is to describe the sous vide process followed for the recipe. This will identify which step is used to pasteurize or thermalize the product. That will be the CCP.

The temperatures measured in the sous vide recipe should be documented so the safety of the process can be verified. Ensure the final internal temperature of the food before service to the customer is measured and recorded. This must be done AT LEAST ONCE to validate the recipe. If a change occurs in the sous vide process, for example, new equipment is used, the recipe changes, or the weight (thickness) of the food portion changes, the recipe should be re-validated.

Figure 4 shows the basic sous vide process: waiting for the water bath to reach the desired temperature – described by Chefs as equilibrium cooking, and by food safety professionals and EHOs as the come-up-time (CUT); the next step is to hold food at that temperature for a specific period of time – for Chefs the goal is to achieve tenderization without compromising flavour or colour, for EHOs it's the certainty that foods are pasteurized and have achieved the appropriate log reduction. The result will be both safe and delicious food.

To properly record the information for your sous vide process there are a minimum of two items to monitor, and for both items you need to record both the time and the temperature:

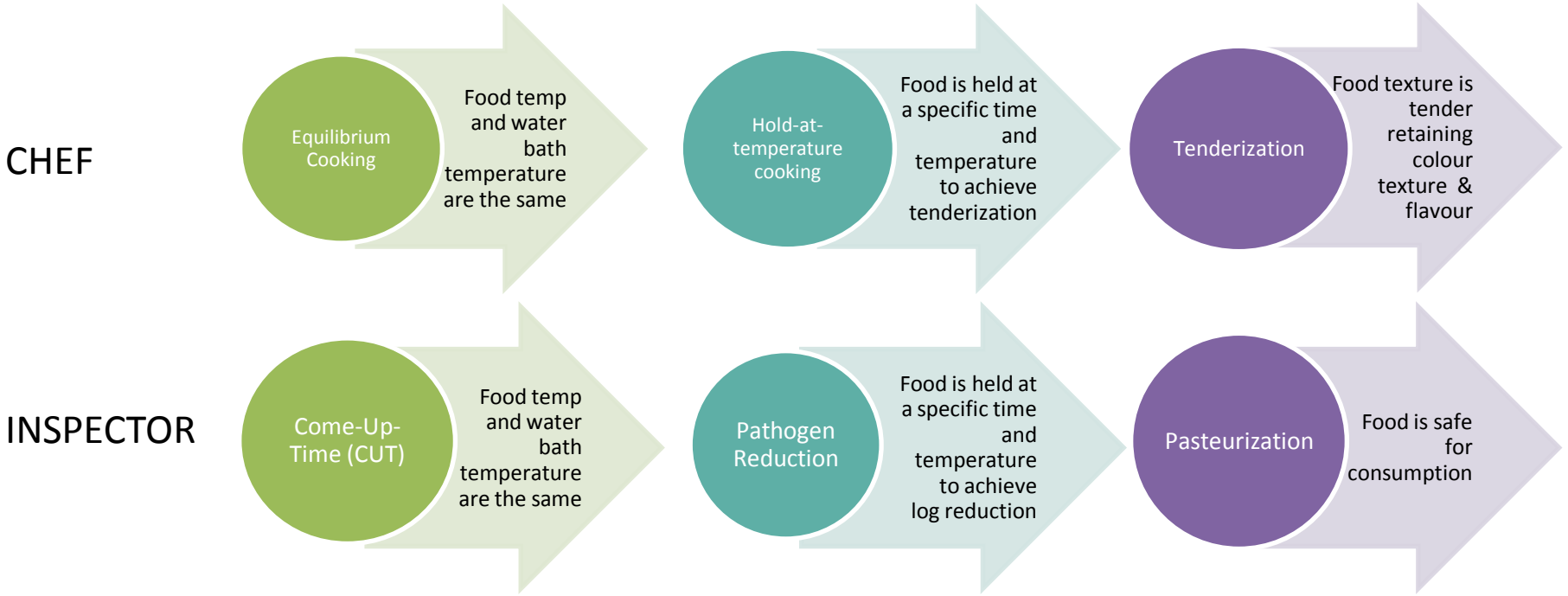
(1) set ***temperature*** for the immersion circulator and the amount of ***time*** for the sous vide foods to reach equilibrium at that setting (CUT)
(2) Internal ***temperature*** of the food and the amount of ***time*** the food is held at that temperature to achieve sous vide pasteurization (must meet or exceed values in Table 3).

How important is recording and keeping foods cooked sous vide style at the proper temperature during the "hold-at-temperature" cooking step? Have a look again at Table 3. Even a very small deviation in temperature can greatly affect the final amount of time required for full pasteurization. Meats, for example, cooked at 55.6°C will require 71 minutes of hold-time to achieve pasteurization. Meats cooked at 55.0°C, a less than 1 degree Celsius (<1°C) difference (or 1 degree °F), will require an extra 18 minutes for a total of 89 minutes to achieve pasteurization.

Establishing the times and temperatures for the CCPs in your recipe are critical for food safety. As even small fluctuations in temperature can affect the outcome, we recommend precise and consistent temperature control during sous vide style cooking.

Figure 4 – The goals of Chefs and EHOs are compatible: producing delicious and safe food

This figure shows the different languages that Chefs and EHOs use to describe sous vide. The process is the same. The result will produce delicious and safe food.



Seafood cooking sous vide style

SOUS VIDE SEAFOOD CONTROLS
(WHEN NOT FULLY PASTEURIZED)

1. FREEZING FOR PARASITE DESTRUCTION
2. CONSUMER DISCLOSURE

Pathogens like *Salmonella* are present in seafoods as well as meats and poultry. Seafoods, however, do not stand up well to higher temperatures. Chefs may use high heat either before or after cooking sous vide style to add grill marks or colour to these foods. Only by measuring the internal temperature of the fish with a needle type probe tip thermometer can the Chef determine the final internal temperature of these foods. As with other types of foods, this working group recommends to cook seafood sous vide to full pasteurization as outlined in Table 3. If that does not occur, these foods are NOT considered thermalized or fully cooked, i.e., bacteria may still be present in the foods. The food safety standard applied is consistent with current knowledge about seafood safe cooking temperatures, even though it is widely recognized that fish muscle tissue is delicate.[1] Seafood cooking that does not meet a 6.5-$\log_{10}$ reduction of bacteria will require two additional controls:

1. Freezing of fish for parasite reduction. The Chef can either ensure the fish received have already met this requirement by asking the supplier to verify freezing control, or, freeze the fish on premises. The standards for freezing for parasite control are to either hold the fish at:[27]
   a. –35°C (–31°F) for 15 hours, or
   b. –20°C (–4°F) for 7 days, or
   c. frozen at –35°C (–31°F) until solid and stored at –20°C (–4°F) or below. (Note that these conditions may not be suitable for freezing particularly large fish (e.g. thicker than six inches).

2. Consumer disclosure is also recommended. This may take any of the following forms:
   a. Menu warnings
   b. Signs posted
   c. Verbal disclosure by staff when these foods ordered

Sous vide style salmon
Photo courtesy of Chef T. MacDonald, VCC

The rationale for the first requirement follows the food safety standard for the service of sushi and sashimi product. Note that there is an exemption for freezing for certain species of tuna and farmed fish, as outlined in the BCCDC "Guideline for the Exemption of Certain Species of Tuna and Farmed Fish from the Parasite Destruction Processes (Freezing) Prior To Service In a Raw or Lightly Cooked Form".[27] One sous vide recipe reported for salmon was to cook sous vide style at 53°C for 20 minutes. When this recipe was replicated in the laboratory, it was found that there was a less than a 2 log reduction in the bacteria naturally present on salmon.[28] Raw salmon tested in this experiment naturally had over four million (4,677,351) bacteria present. After cooking sous vide style, the bacterial numbers were reduced to over 2 million (2,187,761) bacteria present. [28] If any of these bacteria were pathogenic, consumers (especially those

The fragile nature of fish tissue results in a delicate balance between proper cooking (to inactivate the pathogen of concern) and overcooking for optimal eating quality of fishery products. However, food safety should take precedence over eating quality whenever possible

NACMCF, 2008[1]

at risk) may become ill from eating this fish. When a customer goes into a sushi restaurant, they are aware that this fish is raw, and knowingly choose to eat this food. However, sous vide style cooked seafoods may look fully cooked to the consumer. That is the rationale for the second recommendation, that disclosure by the Chef to their customers allows the customer to make an informed choice. This is especially important for at risk individuals, such as pregnant women, who would like to take extra precautions to keep themselves and their babies safe. More about consumer disclosure is found in section 6 of this guideline.

Risk of histamine in tuna and mackeral. Sous vide temperatures of less than 45°C are NOT recommended, as bacteria capable of converting tuna muscle histidine to histamine are capable of growth up to these temperatures. Further best practice is to limit the time tuna is spent out of temperature control, as cold-tolerant bacteria can grow down to 0°C. To limit the risk of histamine formation, when thawing, marinating or preparing raw tuna prior to cooking or service, keep tuna refrigerated.[29]

Shell eggs and cooking sous vide style

Although raw shell eggs do carry a risk of *Salmonella* contamination, shell eggs can be safely prepared in the sous vide style, as long as proper conditions and handling are met. An example recipe for sous vide pasteurized shell eggs is to thermalize the eggs to an internal temperature of 62° to 63°C. The equilibrium cooking time is a minimum of 30 minutes, and holding times a minimum of 15 minutes. Chefs must establish their own times and temperatures through in house testing. Chefs are advised to follow these guidelines when preparing sous vide shell eggs:

1. Raw shell eggs must be fully immersed in the immersion circulator so that all parts of the egg are exposed to the water;
2. Eggs must be held in a perforated container that does not impede heat exchange and water circulation around the eggs;
3. The number of eggs prepared in the immersion circulator must not exceed the heating capacity of the circulator, as demonstrated and documented through in house experimentation;
4. The food safety plan for preparation of eggs must specify both the equilibrium cooking (come-up-time) and holding at temperature cooking time to achieve a 7 log reduction of *Salmonella* (this will be the same pasteurization time as for poultry in Table 3 of this guideline);
5. Eggs cooked sous vide style should be either served, hot-held at or above temperatures of 55°C or cooled and refrigerated;
6. Eggs should be rapidly cooled in a 50:50 ice-water bath, and once cooled, held under refrigerated conditions before use;
7. Eggs should be treated as a PHF, and generally handled as any other sous vide style prepared food is handled, consistent with these guidelines.

3. Equipment and supplies

Common equipment for sous vide processes

Convection steam oven. Also known as combi steamer ovens, convection steam ovens use circulating heat (convection) and steam to prepare foods. Cooking times and loss of product moisture and shrinkage are also reduced. To create the water vapour these machines either use a steam generator or inject measured amounts of water at periodic intervals to the heating elements, resulting in more controlled temperature and humidity, resulting in gentler cooking methods. Pre-packaged sous vide foods can be placed into the oven directly, or, foods may be pasteurized first, then packaged after the process.

Sous vide machines. Water immersion circulator, heating coil, controller.

Sous vide machines are made up of three basic elements:

(1) a heating coil,

(2) a water circulator (pump), and

(3) a controller or device to operate the machine (PID controller).

Polyscience Immersion Circulator

https://www.cuisinetechnology.com/sousvide-thermal-circulator.php

While sous vide pasteurization could be achieved in a warming tray (bain marie), this is not recommended, as without a circulator, keeping a constant temperature without cold and warm spots would be difficult. Sous vide machines may be purchased as a single unit, higher end models include stainless steel reservoirs and lids, or the circulator and heating coil may be purchased separately. Polycarbonate reservoirs (with or without lids) are an inexpensive alternative and considered dishwasher safe. Water circulators on a standard sous vide machine can be set for low or high circulation, Polyscience machines range from 9 LPM (litres per minute) to 15 LPM. The temperature settings are set independently, and many machines allow pre-set temperature settings to be programmed. Some machine controllers allow external probe thermometers to be wired in, so that the internal temperature of foods can be measured (for example, with the Polyscience device, a “hypodermic” thermometer probe can be purchased with the unit).

We do not recommend performing sous vide pasteurization in a device without water circulation. Water temperatures in devices without adequate circulation will have cold and warm spots, will be slower to equilibrate, and once chilled foods are added slower come up times to the set temperature will also occur.

We do recommend setting the immersion circulator to temperatures 1 to 2°C above the desired final internal temperature of the food. As with the example shown earlier (the chicken breast), the food takes some time to come up to the correct temperature. This advice is recommended by Chefs such as Myrhvold (2012) who explains that immersion circulators are only accurate to within ±1 to ±2°C. Setting the immersion circulator temperature a few degrees higher is the best way to achieve equilibrium cooking, when food temperature and water temperature are equal, and to ensure the food is fully cooked.[22]

Thermometers. Probe-tip thermometers sensitive to ±0.1°C and NIST certified (traceable) are recommended. Probes with a thin needle (1mm) are best for a variety of foods thicknesses. Thermometer guns that use infrared sensing beams are not recommended, as they cannot be used to measure the internal temperature of foods. Sous vide cell foam tape should be applied to vacuum packaged foods before inserting the probe tip of the thermometer into the food to protect against leakage of fluids into or out of the sealed bag.[8]

from left: cell foam tape, thermometer and needle tip probe
Photo courtesy of Chef T. MacDonald, VCC

Sous vide Packaging and Vacuum Pouches

There are many different types of plastic materials, not all are suitable for use in sous vide. Sous vide bags should be of high barrier film that is impermeable to oxygen and thick enough to be resistant to punctures from bones and sharp food edges. The thickness of bags is recommended to be at least 2 mil or higher to be oxygen impermeable. Oxygen transmissibility through plastic will vary with the type of plastic used. High and low density polyethylene and polypropylene bags are acceptable for sous vide. Vinyl chloride polymers are not.

We recommend using vacuum pouches specifically designed for sous vide use that are properly vacuum sealed. We do not recommend the use of plastic bags tied with string. Poor vacuum and leakage of fluid into the bag (or out) may result. We do not recommend using Zip-loc® or similar resealable bags for sous vide. Sandwich bags are only 1 mil thick, and not designed nor tested for sous vide use. Zip-loc® freezer bags are 2.6 mil in thickness, and storage bags are 2.0 mil in thickness. When we contacted the company, SC Johnson, we received the following information (see quotation).[30]

> *"Our Ziploc® bag products are made from polyethylene. The bags are suitable for food contact use for microwave defrosting and reheating, room temperature, refrigeration, and freezing unless otherwise noted. Furthermore, Ziploc® Brand Plastic bags are made in accordance with Good Manufacturing Practices (21 CFR Part 110). Please know these bags should be used only according to label directions – they have not been designed or tested for boiling or sous vide cooking. At this time, we do not manufacture a bag for this purpose."*
>
> *[S. Miller, SC Johnson, 2014]*

DO NOT USE SANDWICH ZIP-LOC BAGS FOR SOUS VIDE

USE APPROVED SOUS VIDE PACKAGING FOR SAFETY AND STRENGTH

Vacuum-packager. There are several types of vacuum packagers.[31]

1. External sealer. The bag is placed on the outside of the sealer, air is withdrawn and sealing occurs outside of the sealer.

External vacuum sealer
http://www.foodsaver.ca

2. Chamber type vacuum packager, single or double chambers. The bag is placed inside the packager, and once the lid is closed air is removed from both the chamber and from the inside of the bag. The same pressure now exists in the chamber as inside the bag. The bag may expand slightly as air in the chamber is removed faster than from inside the bag. The bag is sealed, and air is allowed into the chamber, this atmospheric pressure forces the plastic bag to collapse snugly around the food. There are 3 settings required (1) amount of vacuum; (2) post-evacuation required (for porous foods); (3) amount of sealing time.[8] These machines are the most common types used for sous vide foods, as they are able to handle liquids.

Chamber vacuum sealer
https://www.polyscienceculinary.com/chamber-vacuum-sealer.php

3. Automatic belt vacuum and thermoforming (rollstock) vacuum packaging machines are meant for high-speed packaging, larger items and not generally used for restaurant sous vide practices.

How much vacuum is appropriate for the food? It depends in part on the texture and type of food being packaged. Maximum heat transfer from water to the packaged food will occur with the highest vacuum setting, and this is appropriate for hard vegetables. However, softer foods such as fish will be crushed under high vacuum, and the texture lost. Porous foods, such as fruits, also need less vacuum, unless the intent is to compress the food.[7] Caution should be exercised when vacuum packaging foods with bones that might pierce the bag. Generally chamber type vacuum packagers have vacuum settings of low, medium or high. Sensory qualities may dictate what setting is chosen, in a study of beef gluteus higher vacuum was associated with increased perception of juiciness, tenderness, and beef flavor intensity.[32]

When handling sous vide pouches filled with liquids, depending on the type of vacuum packager you use, it may be difficult to achieve a seal without the fluid leaking out. Some manufacturers may use an inclined shelf or dropdown zone in their vacuum equipment that works well for liquids. If you don't have a suitable vacuum sealer for liquids, it is acceptable and likely safer to use the water displacement method before sealing the package.[22]

Glass Jars. Glass is an excellent heat conductor and acceptable container for sous vide cooking for sauces and other foods that would not require a vacuum seal (e.g. pate). Avoid glass when air pockets would be present in absence of vacuum (e.g. pieces of carrot or green beans). The jars should be tightly sealed so no water from the immersion circulator enters the jar. Glass is also a greener choice, reducing plastic waste.

Cleaning and sanitation

The sanitation plan for your equipment should be part of your overall sanitation plan for the premise. The requirement for a sanitation plan can be found in the BC Food Premises Regulation.[33] In general, the sanitation plan should describe four key elements:

1. What is cleaned
2. When to clean
3. How to clean
4. How often to clean

What needs to be cleaned within your facility can be categorized into five areas, (1) food contact surfaces, (2) equipment, (3) attached equipment, (4) structural, and (5) rooms. A sous vide equipment example for "what is cleaned" would be the immersion circulator. This equipment should be cleaned and sanitized as well as have a routine maintenance. The next question "when to clean?" is asking if the equipment should be cleaned before the shift, at the closing of the shift, or at some other time period. Before answering this question, consider the best times that will minimize chances of cross-contamination with ready-to-eat foods, will reduce microbial loads, and will fit the schedule of the premise. The third question will be specific to this equipment.

How to Clean the Immersion Circulator. The basic process for cleaning and sanitizing any piece of equipment or premise structure is outlined in the diagram. In the case of the immersion circulator, to prepare it for cleaning, the unit would need to be unplugged, the circulator and controller removed from the reservoir tank, and the water emptied and discarded. A mild detergent cleaner could be used to remove dirt and soil from the metal reservoir tank, and from the coils and structure of the controller. All parts are rinsed with water before a sanitizing solution is used. The choice of sanitizing agent chosen depends on the material, for stainless steel reservoirs, quats or very hot water (77°C) would work well.

The last question, "how often to clean", is asking about the frequency of cleaning. In the case of the immersion circulator, some Chefs may decide to empty the water chamber and clean after every sous vide pasteurization is completed. Or, the how often might be twice per day, timed as "when" to be after breakfast and lunch service, and again after dinner service. What if a sous vide pouch leaks some contents into the water? Common sense would indicate you would clean and sanitize when this occurs, and the written procedure should include this also. How often to clean may be dictated by how much use the equipment gets. If there is not much use, it may make more sense to change the water in the immersion circulator daily, but only clean and sanitize once per week.

A written sanitation plan should contain the elements above, written as an easy to understand procedure for the staff to follow.

4. Sous vide process procedures

Initial preparation and vacuum packaging of sous vide foods

Chefs may choose to place grill marks on food, may add a marinade or hot blanch foods before vacuum packaging (also known as sous vide pouching). During preparation, an important control point would be to limit the time raw animal proteins (meat, poultry and seafood) are not held refrigerated or "under temperature control". We recommend once these foods are removed from refrigeration to either re-chill or proceed with sous vide style cooking within 2 hours – an EHO would describe this as "raw animal proteins should not be held out of refrigeration for longer than 2 hours". Once foods are prepared for sous vide but before they are vacuum-packaged (sous vide) or cooked, there are several control points to follow: chill foods before sous vide to ensure good vacuum sealing; label pouched foods; and store all raw sous vide foods for a maximum of two days. If you are not proceeding to a sous vide cook process immediately, a critical control point (CCP) to be aware of is to chill sous vide foods to below 3°C by placing on ice in the refrigerator (to control for the *C. botulinum* hazard).

Follow these guidelines for optimal and safe vacuum packaging of sous vide foods

- Foods must be chilled before vacuum packaging – this is a quality and not a safety issue. Air pressure decreases the boiling point of liquids, foods not chilled before vacuum packaging may overcook or cook unevenly.
- Vacuum package foods in a single layer and avoid overlapping foods within the pouch. This will allow for the most rapid and efficient heat transfer during water immersion. Remember, thicker foods will require a longer equilibrium cooking time, or come up time.
- Vacuum package single servings. If bulk packs are vacuum packaged, all servings must be used at the same time. Opening a sealed vacuum package will reduce the packages shelf-life. Once opened, do not reseal.
- The highest vacuum will allow the most optimal heat transfer. However, high vacuum can damage tender foods. Higher vacuums have also been known to affect taste, such as juiciness, tenderness, and flavour intensity as well as texture [11,32]. Balance vacuum pressure with these factors. Baldwin recommends 90-95% vacuum in a chamber vacuum; pressure of 30-50 mbar/ 0.4-0.7 psi vacuum sealing pressure.[11]

SOUS VIDE FOODS SHOULD BE CHILLED BEFORE VACUUM PACKAGING AND WITH ENOUGH VACUUM PRESSURE TO NOT FLOAT

- Avoid foods with sharp edges that may puncture sous vide pouches.
- Vacuum sealers used for raw sous vide foods should not be also used for cooked RTE foods, unless there is a cleaning and sanitation step in between to avoid cross-contamination.
- An alternate method of vacuum sealing is the water displacement method for sealing foods, this is useful for liquids.

Water immersion procedures

To ensure efficient and reliably reproducible sous vide pasteurization, and optimize heat transfer from the water to the food:

- Sous vide pouches must be fully immersed in the immersion circulator.
    - use a plate or "ball blanket" to keep pouches below water surface
- Sous vide pouches should not float – excess air in the packaging will reduce heat transfer.

DO NOT ADDED CHILLED SOUS VIDE POUCHED FOODS TO IMMERSION CIRCULATORS ALREADY IN USE WITH OTHER FOODS

- Once the sous vide pouches are added to the immersion circulator, DO NOT ADD ANY MORE SOUS VIDE POUCHES during the pasteurization time cycle. Adding cold sous vide pouches reduces the temperature of the water circulator.[28] Foods already in the circulator will take a longer time to come up to the correct temperature, and to achieve equilibrium cooking.
- Water temperature will also be reduced if other foods, such as eggs are pasteurized in the same immersion circulator; or, if cold water is added to the circulator during the pasteurization cycle.
- Do not add too many sous vide pouches at one time. Pouches should not be touching each other. Sufficient space between the pouches will allow for proper water circulation and efficient heat exchange from the water to the food.

What happens to the temperature in an immersion circulator if you add cold sous vide pouches? As you would expect, the temperature goes down, but it can take a surprisingly long time for the temperature to recover (equilibrate), or come back up to the original temperature ("come up time" or CUT).

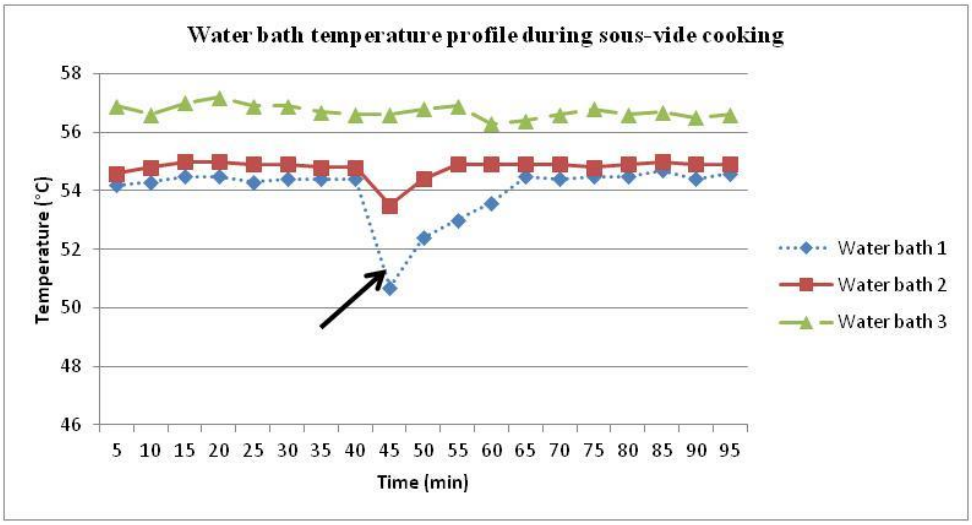


Figure 5 – Water temperature depression after cold sous vide pouches added to immersion circulator

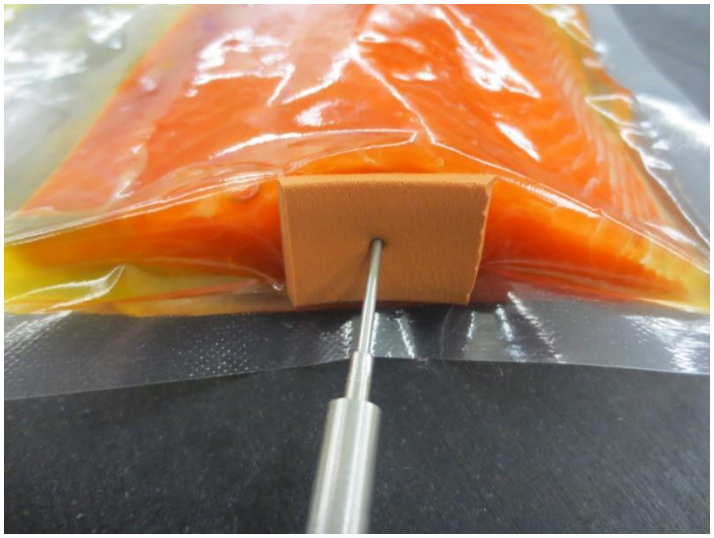
In the figure shown above, real-time temperatures of immersion circulator water temperatures were taken in a restaurant during a sous vide process. In water bath #1, addition of chilled sous vide pouched foods at 40 min resulted in a 3.7°C temperature depression. It took 25 minutes before the temperature fully recovered to the original temperature of 54.4°C (note: the set point of this immersion circulator was 55°C).[28] When this was duplicated in the laboratory, and six chilled sous vide pouches were added

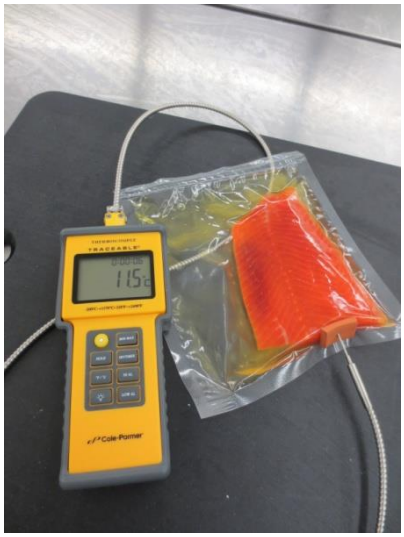
to the a circulating water bath, temperature depressions of 6 to 8°C occurred, requiring approximately 20 to 25 minutes CUT to full recovery.[28] For these reasons we recommend that *NO CHILLED PRODUCT is added to an immersion circulator if there are already foods undergoing a sous vide cook process*. This is more important for foods cooked for less than 6 hours, than for foods cooked for longer periods.

Taking the temperature of foods

Use a needle type probe tip digital thermometer. Apply a piece of cell foam tape to the sous vide pouch where the probe thermometer will be inserted. This will prevent the vacuum from being lost in the pouch, and prevent any leakage when the probe thermometer is inserted and removed. Stick the thermometer into the interior of the food at its thickest point.

PLACE NEEDLE TYPE PROBE THERMOMETER THROUGH CELL FOAM TAPE / SOUS VIDE POUCHES TO MEASURE FOOD TEMPERATURE AT THE THICKEST POINT





Needle probe thermometer inserted through cell foam tape & sous vide pouch into the thickest part of the salmon. Salmon is now ready to be placed into immersion circulator.

Photos courtesy of Chef T. MacDonald, VCC

Finishing of sous vide cooked and sous vide pasteurized foods

From a food quality perspective, finishing sous vide processed foods can add another dimension of flavor and colour. Searing and browning between 140 to 165°C (Maillard reaction) cause reactions between sugars and amino acids (proteins) in food to develop desirable flavors and odors.[34] Grilling, use of a blow-torch, or deep frying are all techniques used to achieve Maillard reactions. From a food safety perspective, if the sous vide cook process fully pasteurized or thermalized the food, then finishing would not be considered a critical control point. However, if pasteurization was not achieved in the water bath and finishing is intended to achieve pasteurization, then this step is a critical control point. Both time and temperature for a reproducible finishing step must be established. These criteria may be difficult to control with each batch of food; we recommend to fully pasteurize foods during the sous vide cooking step.

Cooling, storing, reheating of sous vide foods

Cooling and storage after sous vide and before cooking sous vide style. As previously mentioned, raw animal proteins (meat, poultry and seafoods) should not be held outside of temperature control for longer than two hours. Once sous vide (vacuum-packaging) has occurred, Chefs recommend to keep these foods chilled on ice in the refrigerator. Raw foods should not be held for longer than two (2) days once they are sous vide.

RAW SOUS VIDE POUCHED FOODS MUST BE COOKED WITHIN 2 DAYS

Why is this standard (two days) so much shorter than chill holding of beef and lamb cuts that are held in vacuum packaging between two and five months? These cuts are transported and held at very low temperatures in controlled cold storage. During transportation, temperatures are between –0.5 to –1.5°C, and in cold storage between 1.5°C to 3°C.[35,36] Further, low acid or high pH meat cuts (above pH 6.0) are excluded from prolonged vacuum-package storage, to avoid aerobic bacterial spoilage issues. Finally, all processes are conducted in a HACCP audited facility, including strict hygienic conditions of cattle prior to slaughter.[35,36] In a restaurant, whole cuts are first removed from the vacuum package, sliced into consumer size portions, then repackaged. During this process, the meats are exposed to oxygen, allowing spoilage organisms present to multiply and spreading spoilage organisms to more surfaces on the sliced meat, and the meat itself is further exposed to other potential cross-contamination issues at the site. Restaurants may not be able to maintain very low temperatures of large primal cuts when they arrive (to below 1.5°C), and finally the pH of the foods are not known. Shelf-life of beef products vary on the type of vacuum-packaging used during storage, transportation and retail, with optimal packaging and storage of beef between 60 to 90 days.[37]

Cooling and storage after cooking sous vide style. If a food is not served immediately after the sous vide pasteurization step, it must be cooled immediately. Chefs such as Keller (2008) recommend to cool foods to below 1°C (34°F), and Chefs in this working group agree chill temperatures of 3°C and cooler can be achieved by holding foods on ice in the refrigerator.[7] The best method to rapidly cool packaged sous vide foods is in an ice bath using at least 50% ice and water. Add more ice once it begins melting from the heat of the bags.[7] Cold storage to 3°C and below is important to control for bacteria that survive the low–temperature long–time sous vide pasteurization process.[3] The food safety standard maximum acceptable temperature for storing all vacuum-packaged sous vide foods (raw, cooked or pasteurized) is 3.3°C.[6,38] There are two reasons for this temperature: (1) the temperature during sous vide cooking or pasteurization is insufficient to destroy spores during these process steps; and (2) it is unlikely or unknown if any additional hurdles (low pH or high acid) exist in the sous vide packaged food that would allow for higher refrigeration temperatures.[6,10,38]

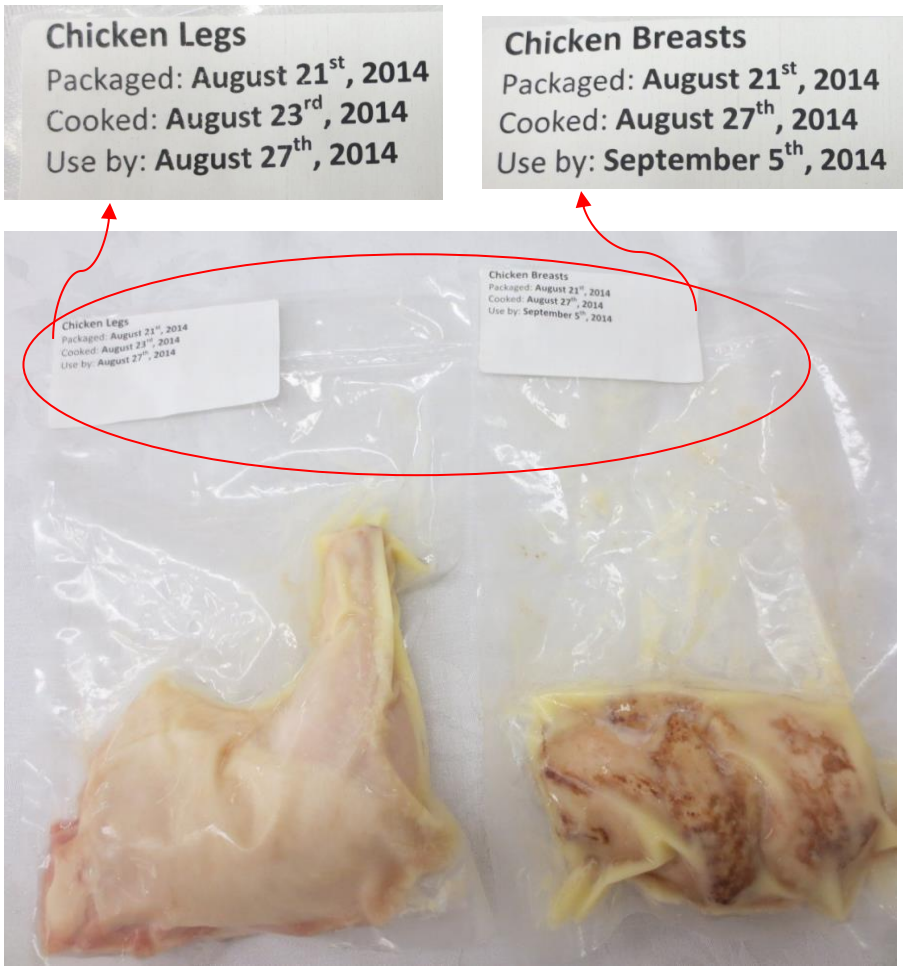
IF NEEDED, USE ICE AND PLACE SOUS VIDE POUCHES AT THE BACK OF THE REFRIGERATOR TO MAINTAIN TEMPERATURES BELOW 3°C

How can you achieve refrigeration temperatures at or below 3°C in a refrigerator? If refrigerated storage at the establishment cannot reliably achieve cold storage temperatures, we recommend that additional steps be taken to reduce the temperature in the refrigerator. One way is to keep sous vide pouched foods near the back of the refrigerator, where it is colder, and where foods are not exposed to warm air as often when the door of the refrigerator is opened. Another way is to layer the sous vide pouches in

ice in a sealed container. Ideally, a refrigerator capable of keeping sous vide pouched foods at or below temperatures of 3°C can be purchased.

In one report, sous vide foods such as chicken, foie gras, pork loin and veal prepared in a restaurant premise did not exhibit any bacterial growth for over two weeks.[39] In this report the foods were sous vide pasteurized (in a steamer oven), vacuum packaged to 98% pressure, cooled rapidly between 30 minutes to 2 hours to below 3°C and held in cold storage below 3°C. At 15 days, all aerobic colony counts were below 100, and even after 30 days in most foods counts were either below 1000 or 10,000 bacteria. [39]

Chefs recommend to use chilled and cooked sous vide style food within three (3) days. The food safety standard we recommend following is the FDA guidance for storage of sous vide pasteurized and cooled foods. At refrigerated temperatures, the maximum acceptable storage time is seven (7) days. These foods must be labeled with the date and time prepared, description of the food and discard date.



Left: **Acceptable** handling of chicken leg indicated on label

Right: **Unacceptable** handling of chicken breast indicated on label

Photos courtesy of Chef T. MacDonald, VCC

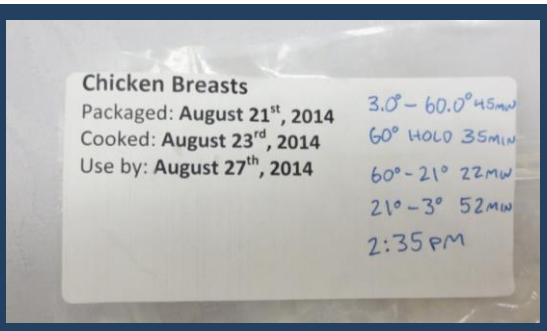
In the photo at left, the chicken leg label indicates an ***acceptable practice***: within 2 days of packaging the raw chicken leg was cooked. The use-by date is within 7 days of sous vide cooking. For best practice, use sous vide cooked foods within 3 days.

On the right hand side of this photo, the chicken breast label indicates an ***unacceptable practice:*** the breast was packaged raw, then held for 7 days before sous vide cooking. The use-by date is also too long (>7 days).

Verification procedures

A written record of verification procedures should be kept to demonstrate the complete sous vide process. A certified, traceable thermometer should be used when performing verification checks. Digital probe tip thermometers sensitive to an accuracy of ±0.1°C are recommended.

Verifying a sous vide recipe. Sous vide recipes must be verified by first checking and recording the internal temperature of the food with a needle type probe tip thermometer. Secondly, the amount of time the food was held at that temperature to achieve pasteurization must be recorded. Is the target (sous vide) temperature being reached during pasteurization or during the finishing step? Was thermalization achieved? How long was the food held at this temperature? This verification should be documented and dated. See example below.



Verification of chicken breast cooked sous vide style

Photo courtesy of Chef T. MacDonald, VCC

Verification Times		Regulatory requirement
Equilibrium / CUT	45 min	< 4 hours
Hold for Pasteurization	35 min	*minimum* 16.9 min
Cooling to 21°C	22 min	≤ 2 hours
Cooling to 3°C	52 min	≤ 4 hours

- *Keep the verification record on-file*
- *Repeat every 6 months, or when the recipe changes*

This will not be a simple procedure, several temperatures will need to be taken through-out the SVP. However, once a sous vide recipe is established and verified, it is not necessary or expected to check the internal temperature of every unit of food for every batch, as long as the food is being cooked sous vide style to either full pasteurization, or to full thermalization during the finishing step, and handled in the same manner as during the verification trials. Periodically, and when the recipe changes, Chefs should check that the recipe is still performing correctly to their specifications.

Verifying the temperature of water circulator equipment. If there is an internal calibration function on the equipment, follow the instruction from the manual. To externally verify the temperature, an acceptable method would be to put a probe tip thermometer or smart button data logger into the equipment and to let the temperature setting stabilize. The thermometer and logger should be suspended, not touching or sitting on the bottom of the circulator. Compare the value found on the probe tip thermometer or data logger to that of the water circulator. Should the water circulator read above or below the value of the thermometer, record this value on a sticker or piece of tape and apply it to the water circulator. For example "display reads –1.0°C from actual". If the desired temperature setting is for 65°C, this device must be set at 66°C to reach that temperature.

Verifying the thermometer. To provide assurance that the thermometer you use is within specifications, an annual verification of the thermometer should be performed. Many laboratory instrument companies are available to provide this service. Thermometers should be returned with a certificate of calibration, and may have an adjustment applied to them. Keep the certificate of calibration with your records.

VERIFY TEMPERATURES IN YOUR SOUS VIDE RECIPE USING A PROBE-TIP THERMOMETER & CALIBRATE YOUR THERMOMETER ANNUALLY

To perform thermometer verifications in addition to the annual check, we recommend you check your thermometer in an ice-water bath and with boiling water. Consult this site for more information. http://www.nist.gov/pml/mercury_validation.cfm

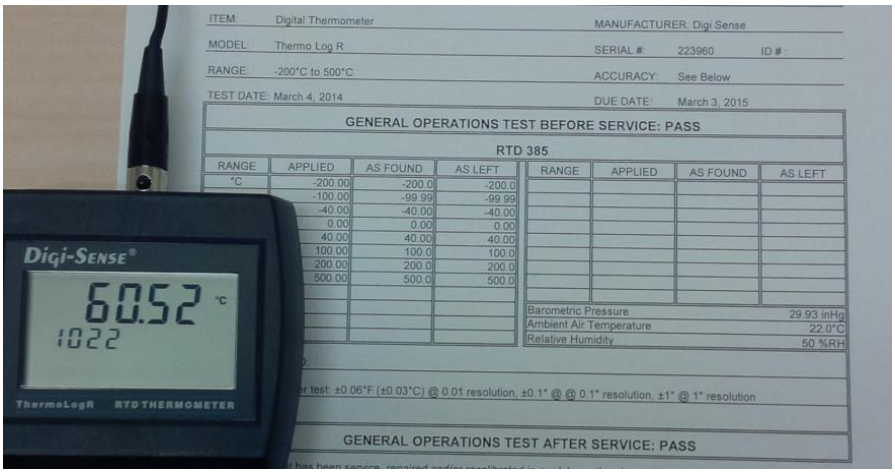


Photo courtesy of S. Shyng, BCCDC

Verifying the cooling procedure. To verify a cooling procedure keep track of the time and temperature during the cooling process. For example, Chefs recommend cooling foods to below 3°C within 2 hours of removal of the water circulator. You prepare a large ice-bath and add 10 bags of sous vide prepared chicken breasts. After 30 minutes, you add more ice and measure the internal temperature of one of the chicken breasts. It measures 8°C, so you leave all the bags in the ice bath for another 30 minutes. After one hour, you re-measure the temperature and it reads 1°C. The chicken is ready to place into the refrigerator.

Stock rotation (first in first out rule). Sous vide pasteurized foods, if not served immediately, should be cooled then labeled properly. Acceptable labeling includes product name, date, time and discard date [8]. Chefs recommend foods to be used within 3 days of pasteurization if stored refrigerated [7], the food safety standard maximum allowable time for fully sous vide pasteurized foods to be used is 7 days [20]. After this time these foods should be discarded. If pasteurized sous vide pouched foods are stored frozen, they may be stored until use.[20]

Best practices for sous vide processes, in the form of a "Do's" and "Don'ts" checklist are given in Appendix 1.

5. Food safety plan expectations

A FOOD SAFETY PLAN IS A REQUIREMENT UNDER THE *BC FOOD PREMISES REGULATION*; IDENTIFY THE CCPS AND CRITICAL LIMITS

A food safety plan will help everyone understand how the food is prepared, what ingredients go into the food, define the CCPs and critical limits, describe what should happen to the food if CCPs and critical limits are not achieved, describe what should happen to leftovers, and be understandable and useable. The food safety plan should be written by the Chef. Having a food safety plan is a requirement under the *BC Food Premises Regulation*.[33] The general expectations for a food safety plan (FSP) are shown in the table below.

Table 5 – Basic components of a food safety plan

FSP component	Description
Food product	Identify each food product being prepared
Ingredients	Provide a list of ingredients for each food product
Process	For each product, provide a stepwise description of the process used to prepare the product – flow chart or table form is recommended
CCPs	For each process, identify which steps are Critical Control Points. CCPs during a sous vide process may be one or more of the following: internal food temperature and hold time measured for sous vide pasteurization, cooling after SVP, cold storage, hot holding, and finishing step before service.
Critical Limits	For each CCP, the critical limits for that step should be clearly identified. For each critical limit, the following should be identified: • **how** it will be monitored (e.g. temperature and time measurements recorded on log sheets) • **how often** it will be monitored (e.g. daily, every time product is prepared) • **what** corrective actions are required if the critical limit is not met

Where can a Chef start with a food safety plan? One way is to look first at the recipe. One example is taken from a recipe provided in *Modernist Cuisine at home* by Myhrvold (2012).[22] In the sous vide chicken recipe, the chicken breast is cooked to a core temperature of 60°C. To do this the vacuum packaged chicken breast is immersed in the circulator for 40 minutes to come up to the correct temperature (CUT=40min) or to establish equilibrium cooking. Then the chicken breast is held at 60°C for an additional 20 minutes to fully pasteurize. Myhrvold calls this "hold-at-temperature" cooking. If we consult Table 3, that lists the time and temperature values for a 7-$\log_{10}$ reduction of pathogens in poultry, we find that at 60°C the food item must stay at this temperature for 16.9 minutes. The Myhrvold recipe provides an excellent safety margin by requiring 20 minutes.

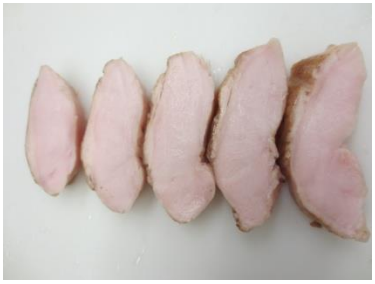
A SOUS VIDE FOOD SAFETY PLAN MUST INCLUDE TIME AND TEMPERATURE DATA FOR "HOLD-AT-TEMERATURE" COOKING AND OTHER CCPS SUCH AS COOLING

When the chicken is removed from the immersion circulator, the chicken may be cooled in ice-water bath, and recipe storage notes say "keep for 3 days when refrigerated". The chicken can be finished by warming back-up in the water bath for 10 to 15 minutes, then seared in a hot, oiled pan. This recipe actually contains most of the detail needed to articulate a good food safety plan, with a description of the process steps, CCPs, critical limits and monitoring outlined in Table 6 on the following page.

Table 6 – Critical control points and critical limits for a Myhrvold (2012) sous vide chicken recipe

Process	CCPs and Critical Limits	Monitoring	Comments
Sous vide equilibrium cooking (CUT)	not a CCP 40 min equilibrium cooking (CUT)	• check water temp is at correct temp before starting • verify with thermometer • use timer	Equilibrium (CUT) of 40 min should be reproducible, documented, and verified on a regular basis.
Sous vide hold-at-temperature cooking (pasteurization)	Internal temp of 60°C for 20 min	• check water temp • use timer • verify recipe with thermometer	Chefs recipe and plan exceeds food safety standard requiring a minimum of 16.9 min
Chilling & Storage	Cool to below 3°C within 30 min Store refrigerated for 3 days	• verify cooling with thermometer • write date on package • discard after date expires	Chefs recipe and plan exceeds food safety standard of cooling within 6 hrs, and storage for maximum of 7 days
Warming	not a CCP	• Warm for 10 to 15 min in bath	
Finishing	not a CCP		Finishing for consumer preference; food safety pasteurization achieved in hold-at-temperature step

An example of a good food safety plan for pork loin chops is shown in Appendix 2 (food flow chart) and Appendix 3 (written food safety plan). Charting out the flow of food in your food safety plan is always an excellent idea. The visual representation of what is happening to the food is extremely helpful, both for you, as the Chef to explain to your staff to understand what is expected, and for your EHO, who is assessing the overall food safety. As outlined earlier in Figure 3, sous vide may be performed in many ways. How you choose to employ this technique should be charted out, and at least one process step must include a CCP and critical limit to ensure the safety of the food being served at your establishment.



Properly pasteurized sous vide pork – slight pink colour does not imply this product is unsafe. Measuring time and temperature is the only reliable way to assure a correct sous vide process.

Photo courtesy Chef T. MacDonald

To illustrate the allowable practices for sous vide the next five figures depict correct and incorrect sous vide food flow charts. Red colour boxes on the food flow charts indicate the CCP. In Figure 6, a classic "cook-chill-serve" for sous vide is shown. The sous vide process step pasteurizes the food; a food safety plan for food prepared in this food flow must state the internal food temperature and time to hold the food at that temperature. A record of the verification data to support this should also include the time for equilibrium (CUT) for the food and equipment (i.e., the water temperature setting and time for food in the immersion circulator).

The total time should also be given at that temperature setting. In Figure 7, it is the finish step (not the sous vide step) that provides for pathogen reduction.

Some additional explanation is required for Figure 9 – an interrupted sous vide process for foods that did not reach temperatures >55°C during the sous vide step. If complete pasteurization cannot be achieved during the sous vide process, and the sous vide pouched food is chilled, then either put back into a sous vide process or thermalized in another way (i.e., searing in a pan), the entire time cannot take longer than 4 hours. Foods remaining in the temperature danger zone must not remain there for more than 4 hours to limit pathogen growth.

WHEN SOUS VIDE TEMPERATURES ARE BELOW 55°C, THE TIME PERIOD TO ACHIEVE THERMALIZATION MUST NOT EXCEED 4 HOURS (FIG. 9)

Figure 10 describes warming of foods prior to service, foods warmed at temperatures below 55°C cannot be held longer than 2 hours, and must be discarded. Foods warmed for service at temperatures above 55°C can be held at or above this temperature without a limit for time. Although the food safety standard for hot-holding in BC states foods must be hot-held at 60°, sous vide foods that have been fully pasteurized and are held within the vacuum pouch are exempted from this requirement. Foods held above 54.4°C will control for growth of *C. perfringens.*[6] We do not recommend cooling sous vide style cooked food leftovers, i.e., those foods already hot-held for longer than two hours. As explained in the definition for rethermalization, these foods could not be rewarmed again before service at sous vide temperatures. They would need to be reheated to an internal temperature of 74°C before service (option not shown in the figure).

To assess a food safety plan, a marking criteria sheet is shown in Appendix 4. This can be used by EHO's and by Chefs interested in assessing their own food safety plans. A food safety plan should meet and describe these outcomes.

6. Informed Customers

Sous vide foods not fully cooked may pose a risk to certain individuals. These individuals include pregnant women, young children, the elderly or otherwise immune-compromised. Customers should know when the foods they consume may pose a health risk to themselves, so that they may make an informed choice. Although no illnesses from sous vide prepared foods have been documented, for certain foods that are only minimally heated (for e.g., fish) customers should be aware they are consuming what are essentially raw products. Disclosure may take the form of:

- Menu warnings
- Signs posted
- Verbal disclosure by staff when these foods ordered

Figure 6 – Sous vide process (sous vide pasteurization is the CCP)

This figure represents a sous vide process where SVP step is the CCP, in a cook-chill-serve food flow. Chill steps are always CCP.

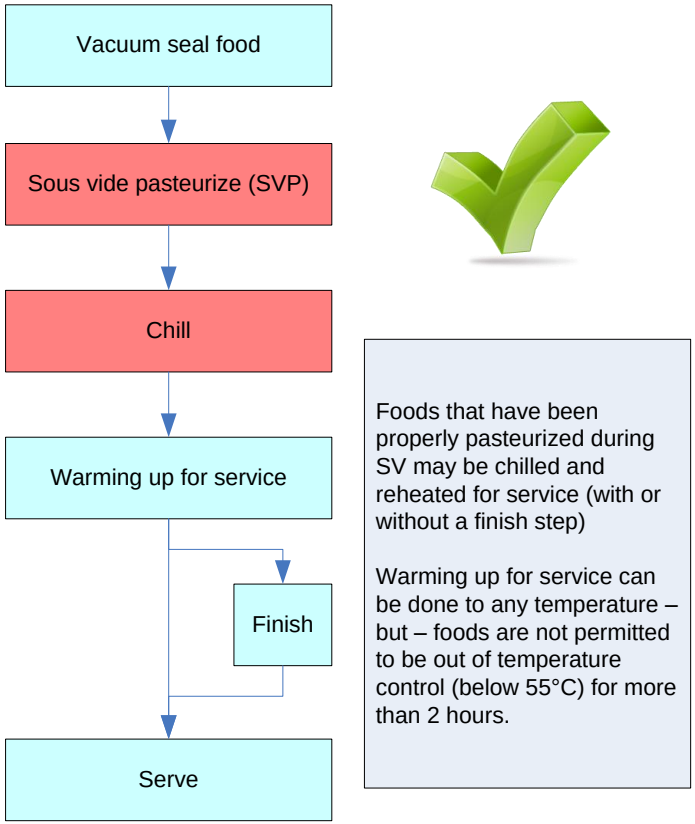


Figure 7 – Sous vide process (finishing is the CCP)

This figure represents a continuous process (cook-serve), when the initial sous vide heating step does not fully pasteurize the food. In this process the finishing step is the CCP.

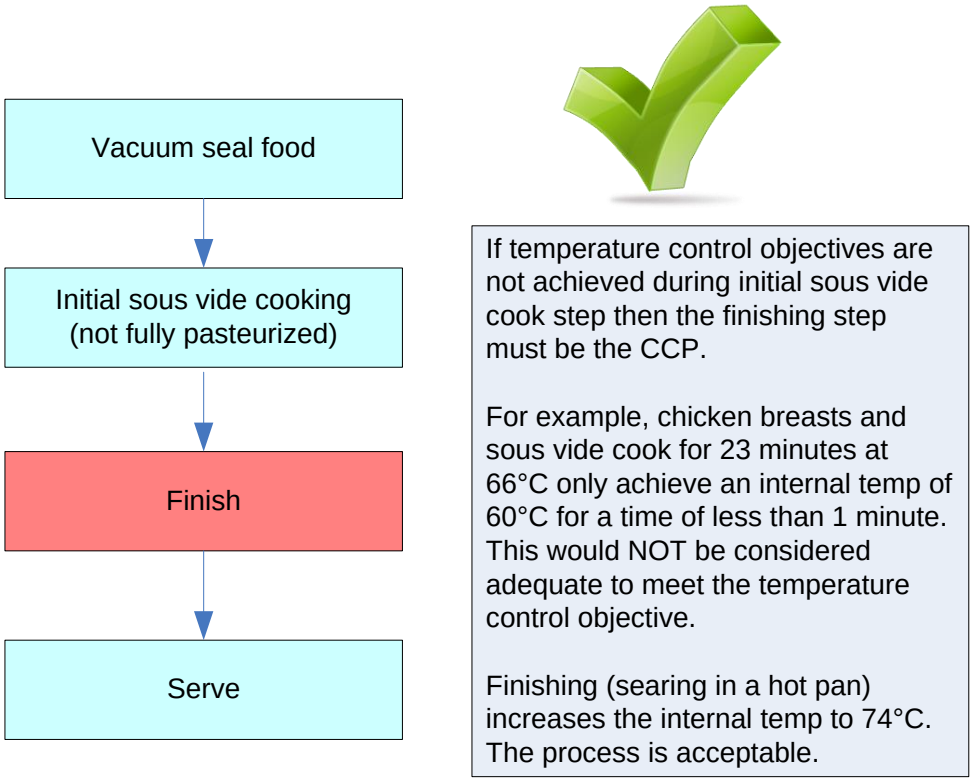


Figure 8 – Incorrect sous vide process

This figure represents an incorrect sous vide process (cook-chill-serve). There is no step that fully pasteurizes or cooks the food. The food is raw. Without a cook step, the food is considered temperature abused.

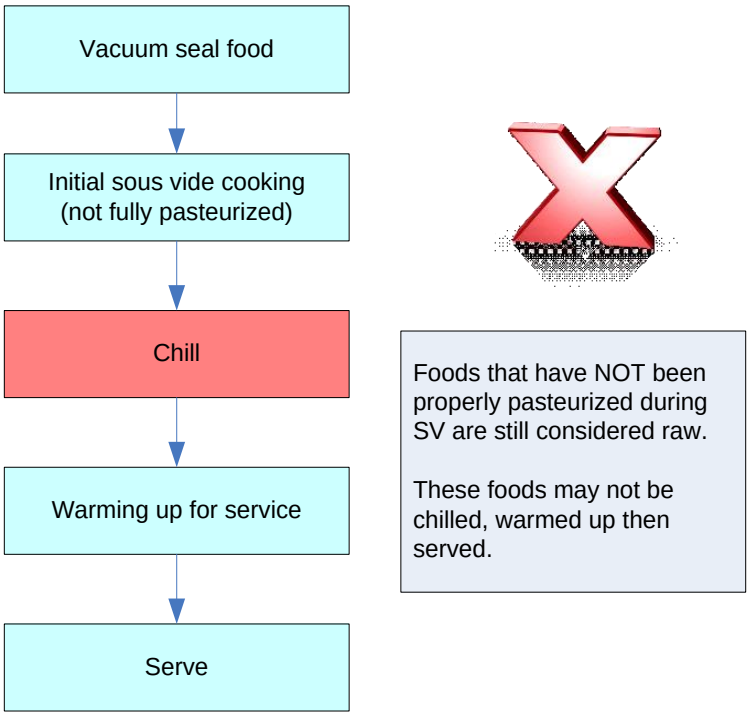


Figure 9 – Interrupted sous vide process

This figure represents an interrupted process (cook-chill-serve), when the initial sous vide heating step does not fully pasteurize the food. The cumulative time between the initial and final sous vide pasteurization or finishing step MUST NOT exceed 4 hrs.

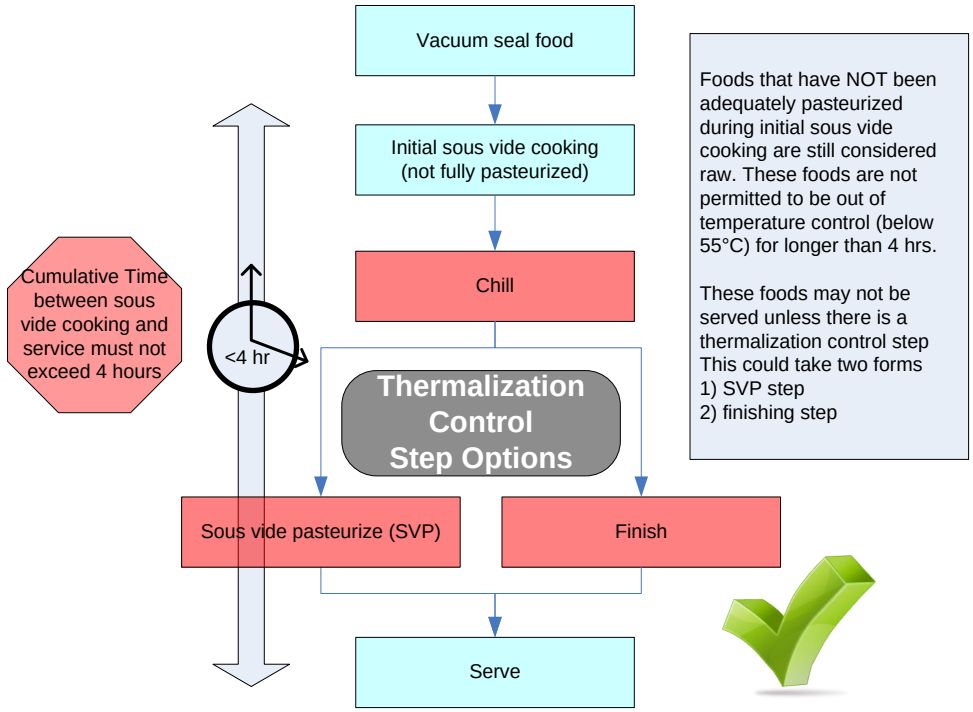
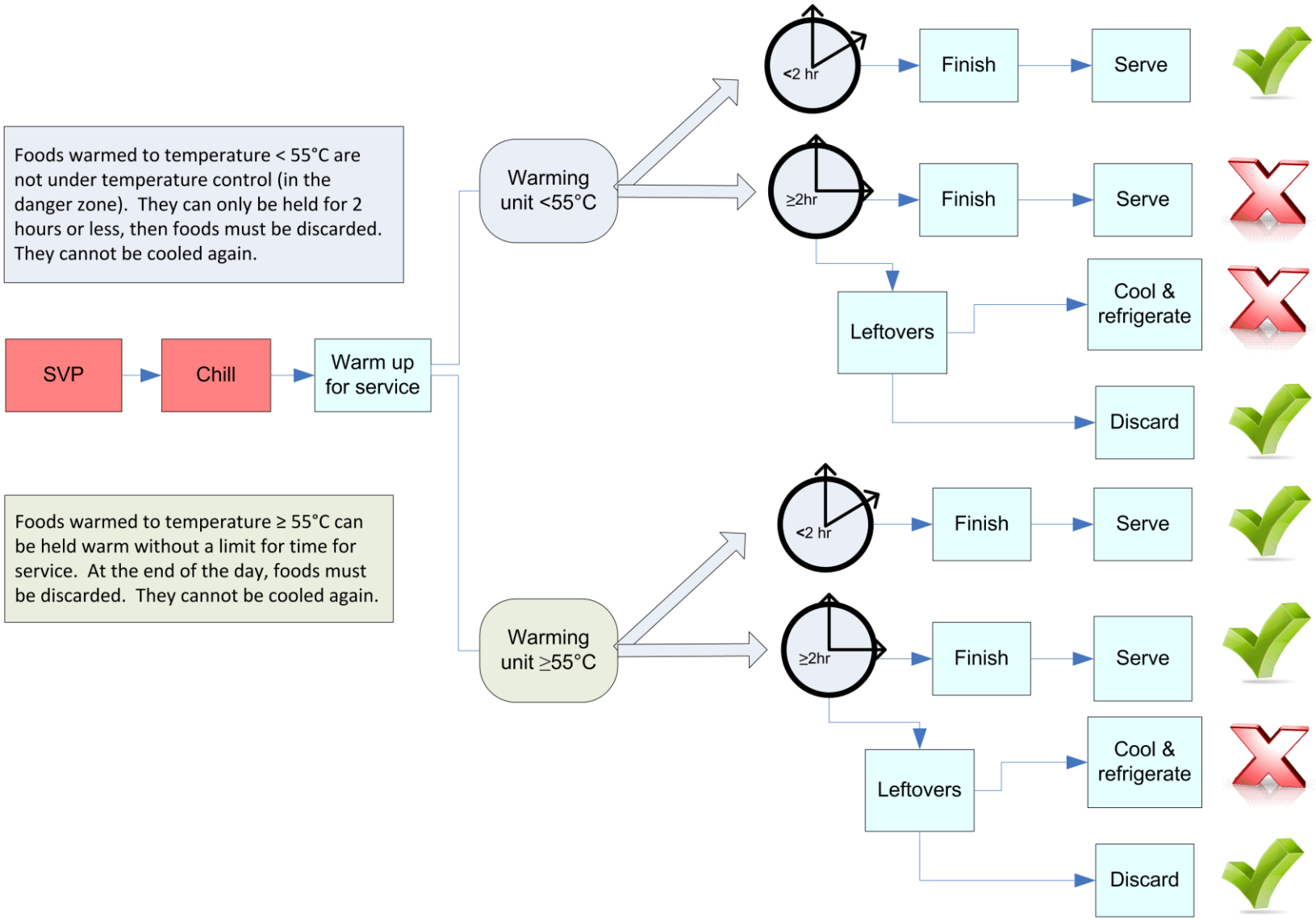


Figure 10 – Warming up sous vide foods for service



7. Catering

Sous vide food preparation is particularly useful for large functions as it allows for the advance preparation of foods. Foods are conveniently packaged reducing the risks with post-processing contamination.[40] The majority of foods cooked sous vide style for catering will be prepared, vacuum-packaged and either cooked or pasteurized at the restaurant site before transport to the catering site. At the catering site foods will be finished and served. These recommendations apply to sous vide style foods in this category only, from the transportation process step onwards.

The following recommendations are made for catering involving sous vide foods:

- All prior recommendations involving the handling of sous vide cooked and pasteurized foods apply.
- Temperature control during transportation is a critical control point. Sous vide pouched foods must be transported under temperature control capable of keeping pouched foods at or below the food safety standard of 3.3°C, and ideally at or below the Chef recommendations of 3°C. This may be accomplished via a mechanically refrigerated transport (vehicle with reefer unit); packing in ice in cooler chest; packing with ice packs in cooler chest; or some other means.
- At the catering site, the premise must be equipped with all necessary equipment and utilities to ensure hygienic handling of foods (i.e. sufficient hot and cold water and soap for hand-washing and cleaning of utensils); chilling of foods; finishing of foods; and warming of foods (or hot-holding) before service.

8. Roles and Responsibilities

Chefs and EHOs both have a responsibility to ensure food safety. However, it is the Chef who is in control of food safety at the food premise. Chefs should know the potential hazards in foods, and the correct way to process food and control food hazards safely. Inspections alone will not guarantee food safety, and they are not the answer to a zero-defect food safety program.[6] The Chefs and management should be training employees to perform sous vide techniques with validated recipes that incorporate the food safety controls discussed in this document. Employees unsure of how to perform processes must be able to consult their supervisors and Chefs for guidance.

Having a written food safety plan for sous vide and for sanitation will assist and inform inspectors seeking to approve the sous vide process employed in the restaurant, will assist employees seeking to correctly follow the recipe, and will assist Chefs when explaining and validating their recipe. "*Chefs look at every batch of food produced, and they know if the food was produced according to the policies, procedures, and standards manual.*" [6]

The goals of Chefs and EHOs are the same, even though the language and the way we describe the sous vide process appear to be different. As shown if Figure 4, sous vide style cooking, when followed to the recommendations of Chefs and food standards of EHOs will result in both delicious and safe food.

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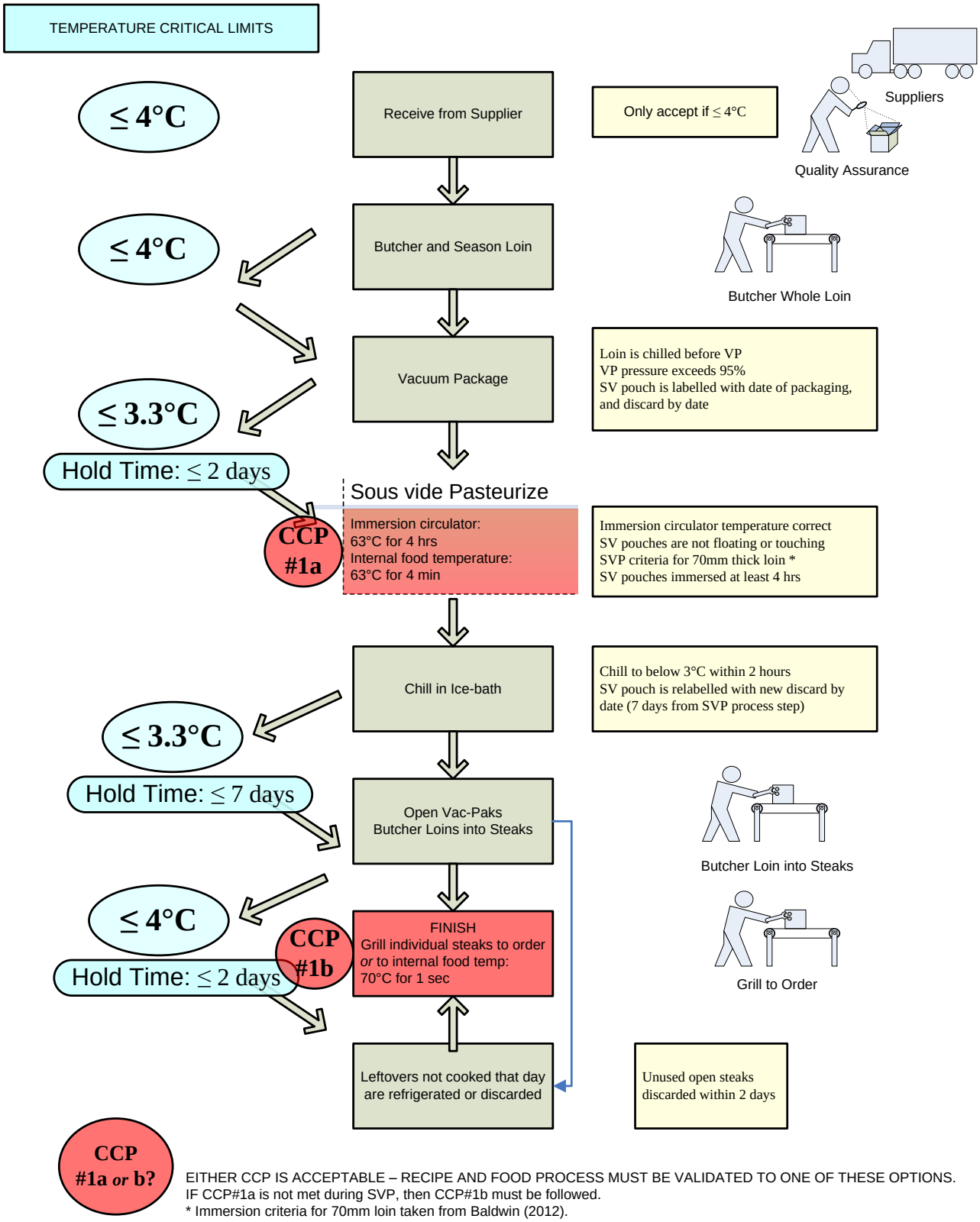
Appendix 1 – Do's and Don'ts for Sous Vide

	DO		DON'T (*you should instead...*)
✓	Chart out the food flow for your sous vide recipe, and create a written food safety and sanitation plan	✗	Use the same vacuum sealer for raw and ready-to-eat foods *(you should have a clean and sanitize step in-between raw and RTE use)*
✓	Use approved packaging, 2 mil or thicker, made of either polypropylene or polyethylene plastics	✗	Use re-sealable (i.e., Zip-loc©) sandwich bags (bags are too thin, and not approved for sous vide use)
✓	Buy a probe-tip thermometer, accurate to ±0.1°C	✗	Tie sous vide packaging with string (*may leak, use a proper vacuum packaging technique)*
✓	Use the thermometer to measure the internal temperature of food (at the thickest part) to ensure the food reaches desired temperature (for recipe verification)	✗	Assess food doneness by colour, texture or taste alone (*you should verify internal temperature with a thermometer*)
✓	Ensure sous vide pouches are fully immersed with good water flow around them	✗	Add too many sous vide pouches to the circulator – causing poor water circulation
✓	Use an external thermometer to verify the immersion circulator is reading correctly	✗	Rely only on temperature displayed on the immersion circulator
✓	Calibrate your thermometer	✗	Add cold water to the circulator during a sous vide pasteurization cycle *(add warm water instead)*
✓	Pre-warm the immersion circulator to the correct temperature setting before adding foods and starting the timer countdown (set to a few °C higher than desired end food temperature)	✗	Add cold sous vide pouches from the refrigerator into the circulator if already in use, i.e., other food is already being heated
✓	Finish (sear, fry etc.) sous vide foods not fully pasteurized during initial sous vide heating step to an acceptable safe temperature	✗	Warm up foods for longer than 2 hours at temperatures below 55°C before finishing and service
✓	Chill sous vide pouched foods (raw or pasteurized) to below 3°C within 2 hours	✗	Store any vacuum packaged food at temperatures above 3°C *(you should keep chill in ice if necessary)*
✓	Discard unused portions of warmed sous vide pasteurized foods after 2 hours of warming	✗	Re-chill unused portions that have been warmed for longer than 2 hours for next day service
✓	Disclose sous vide foods not fully cooked to consumers to allow them an informed dining choice	✗	Serve raw food to consumers without disclosure (i.e. undercooked fish may pose risk to some diners)
✓	Label all refrigerated sous vide pouched foods with date, time, discard date and identity	✗	Leave unlabelled sous vide pouched foods in the refrigerator

Appendix 2 – Food Flow Chart for Sous Vide Pork Loins



NOTE: the CCP addresses the hazard of *Salmonella* for a 6.5 log reduction per Table 3 (pg 14).

Appendix 3 – Food Safety Plan for Sous Vide – a Good Example

Pork Loin Chops Stepwise Description			
1. Loin received whole from supplier, proper temperature below 4°C checked, product accepted			
2. Refrigerated below 4°C			
3. Loin butchered and seasoned using clean and sanitized utensils and in a clean work area, proper hygiene monitored and maintained			
4. Loin packaged in vacuum bags, labeled and refrigerated below 3.3°C			
5. Sous-vide equipment set up and temperature of cooking medium verified at 63°C			
Loin heated sous-vide to internal temp of 63°C and held there for 4 min			
6. to 8. Loin removed from water bath and placed in ice bath of at least 50% ice for 30 min and then refrigerated below 3.3°C			
9. Loin removed from bag, butchered into chops in clean work area with clean utensils and chops reheated on grill to order			
10. Opened vac-pack stored below 4°C, reheated per step 9.			

Food Safety Plan - Sous Vide Pasteurization of Pork Loin Chops				
Step	**Hazard**	**Control Point (Critical in Red)** **Critical Limits in Bold**	**Monitoring**	**Corrective Action**
1. Receiving	Contamination	Foods are obtained from approved sources	Visual inspection and receipt documentation	Reject any product showing adulteration or spoilage
	Pathogen growth	PHFs received below 4°C/–18°C	Temperature measured (upon receipt)	Reject any PHFs >4°C
2. Cold Storage	Pathogen growth	Maintain temperatures below 4°C	Temperature measured with a calibrated thermometer (daily)	Adjust cooler temperature Repair equipment (if required)
			Temperatures recorded on log	Relocate/Discard PHF (as required)
3. Preparation	Contamination	Good Hygiene Sanitized Equipment Adequate vacuum seals on sous-vide packages	Verification of vacuum sealing with proper ROP packaging	Reseal bags with inadequate vacuum seal
4. Cold Storage (if applicable)	Pathogen growth	Maintain temperatures below **3.3°C** once product in VP, otherwise 4°C is adequate	Temperature measured (daily)	Adjust cooler temperature
		Hold no longer than **2 days** before sous vide cook	Temperatures recorded in log	Repair equipment (if required)
			Adhere to use-by/expiry date labels for storage	Discard PHF (as required)
5. Sous vide equilibrium cooking (CUT) & hold-at-temperature cooking (pasteurization)	Pathogen survival	Equilibrium/CUT of 4 hrs at 63°C. Product cooked to corresponding time/temperature combination for 6.5-$\log_{10}$ pathogen reduction **For 70mm loin hold internal temp for 4 min at 63°C**	Measure temperature of water bath	Adjust temperature of water bath
			Use of timers to maintain proper cooking times	Adjust cooking time/temperature (as required)
			Probe internal temperature of food to verify method	Control pathogens at finishing step
6. Hot Holding (if applicable)	Pathogen growth	Maintain temperature above **60°C**	Temperature measured	Reheat if <55°C for <2 hour
			Temperatures recorded on log	Discard if <55°C for >2 hour
7. Cooling (if applicable)	Pathogen growth	Optimal requirement: **<3°C within 2 hr**	Ensure ice bath is at least 50% ice and check temp with a digital thermometer	Discard if time/temperature standards are not met
8. Cold Storage vac-pack loin (if applicable)	Pathogen growth	Maintain temperatures below **3.3°C**	Temperature measured (daily)	Adjust cooler temperature
			Temperatures recorded on log	Repair equipment (if required)
			Storage time (at <3.3°C) is less than 7 days	Relocate/Discard PHF (as required)
9. Finishing (grill chops to order)	Pathogen survival	Product cooked to **70°C for 1 sec** or equiv. time/temp combination	Probe internal temperature of food to verify method	Cook longer if final temperature is not reached otherwise discard
		Required only if pasteurization not achieved during initial sous vide heating, finishing step must be adequate for 6.5-log $_{10}$ reduction	Temperatures recorded on log	Adjust cooking time/temperature (as required)
10. Cold Storage opened loin (if applicable)	Pathogen growth	Maintain temperatures below 4°C	Temperature measured (daily)	Adjust cooler temperature
			Temperatures recorded on log	Repair equipment (if required)
			Storage time (at <4°C) is less than 2 days	Relocate/Discard PHF (as required)

Appendix 4 – Sous Vide Food Safety Plan Assessment

Reviewed for Chef:_____ Food Premise: _____

Plan for : _____ Reviewed by: _____
(name of food or recipe)

Food safety plan style category: ☐ Recipe-based ☐ Process-based

What type of a sous vide pasteurization (SVP) process is this?

☐ SVP→serve ☐ SVP→finish→serve

☐ SVP→chill→reheat→serve ☐ SVP→chill→reheat→finish→serve

Other:

Plan components	Satisfactory	Unsatisfactory	Comments
Is there a food flow chart?	☐	☐	
Are the CCPs clearly identified? (labeled or bold-face type)	☐	☐	
Are the CCPs correct?	☐	☐	
Are the critical limits clearly identified?	☐	☐	
Are corrective actions suggested when critical limits are not met?	☐	☐	
Is record-keeping mentioned for CCPs &/or CL deviations?	☐	☐	
Does the plan mention pre-requisite program components that could be covered elsewhere? (receiving, personnel hygiene, temp control for refrigeration units, sources of water or ice, etc.)	☐	☐	
Does the plan use vague terminology without specifying details? (i.e. "prevent cross-contamination" instead of "use red cutting board for raw meats & white cutting board for cooked meats".	☐	☐	
Does the plan discuss what to do with left-over foods?	☐	☐	
Is the plan understandable? Does the plan make sense?	☐	☐	
Is it practical and useable? Could this FSP be used by the kitchen staff?	☐	☐	
Does the plan specify how to take the internal temperature of the SVP food? ie. to use a probe thermometer and foam tape?	☐	☐	
Is equipment to be used described in the plan?	☐	☐	
Are operating limits specified for each equipment used? What are they?	☐	☐