

# STEAM GENERATION IN ORGANIC FOOD PROCESSING SYSTEMS

## *Background Paper for the Petitions for Ammonium Hydroxide, Cyclohexylamine, Diethylaminoethanol Morpholine, and Octadecylamine*

### **Background**

Live steam is used to process a large number of foods, including many products that are sold as 'certified organic.' Equipment to generate steam and use it for industrial purposes has existed since at least the middle of the 18<sup>th</sup> Century (Britannica, 2001). Efficient use of steam to prepare food beyond household scale was documented by the early 19<sup>th</sup> century (Giedion, 1948). While fuels, metallurgy, control systems, and maintenance programs have changed since that time, the fundamental scientific principles, basic designs, and problems associated with those systems have remained constant. The production of superheated water under pressure suitable for direct food contact—known as 'culinary steam'—requires food-grade equipment, clean water, and sanitary conditions where food contact is a possibility. Food processors have fewer options in metals, water treatments, fuels, and other aspects of steam generation and boiler operations than those who operate boilers for non-food uses, such as electric power generation.

Organic food processors face even stricter requirements than those of non-organic food processors. Because water is a non-organic ingredient, it is not subject to the same requirements as organic ingredients. Unlike any other non-organic ingredient except salt, water may exceed 5% of the weight of a processed product labeled 'organic' and '100% organic' [7 USC 6510(a)(4), and 7 CFR 205.301(b) and 7 CFR 205.301(a)].

Water used in organic processing must meet two basic requirements.

- (1) The Organic Foods Production Act [7 USC 6510(a)(7)] requires that water used in processing meet Safe Drinking Water Act (SDWA) standards [42 USC 300(f) *et seq.*]. If there is unavoidable residual environmental contamination beyond the control of the processor, contaminants in the water cannot exceed the Maximum Contamination Limits (MCLs) established by the SDWA. This is assumed to include water in all of its phases: liquid water is used as an ingredient and processing aid for many operations; ice is used to remove field heat and prevent spoilage of produce; and live steam used in direct food contact for a variety of processes.
- (2) Processing aids used to treat water all fall under the definition of processing aids in 7 CFR 205.2. This states: "a substance that is added to a food for its technical or functional effect in the processing but is present in the finished food at insignificant levels and does not have any technical or functional effect in that food." Such processing aids must either be organically produced or be on the National List. Otherwise, they are prohibited for contact with foods labeled organic (95% organic ingredients) and ingredients represented to be organically produced (7 CFR 205.301).

Therefore, steam purity is of concern to comply with organic standards. Ideal steam is 100% vaporized water. Liquid water, as well as solid, liquid, and vapor chemical contaminants degrade steam purity. These impurities are collectively known as 'carryover.' Carryover is generally classified as either mechanical or vaporous (chemical) (Bellows, 1997). Mechanical carryover occurs from high levels of solids in the water and equipment malfunctions. Vaporous or chemical carryover is the contamination of steam by water-soluble chemicals. Water treatment can help water meet organic standards, but chemical treatments may also jeopardize organic integrity. To understand how water treatments fit in organic standards, it is helpful to have an understanding of why and how these chemicals are used.

### **Conditions Requiring Water Treatment**

Typical problems that occur with steam equipment are pitting, deposition of insoluble compounds (scale), and corrosion. This damage is mitigated through system design, selection of suitable fabrication materials, process control, and the use of controlled dosages of particular substances that prevent or reduce these problems (Kohan, 1997).

Pitting is generally caused by the impact of solids against the sides of a boiler. The best solution for this is the filtration of water to remove such solids (Kohan, 1997). Some filters may use chelating agents to attract and retain solids through chemical reaction. Scale is a coating of thermally non-conducting solids on the waterside of a boiler, usually composed mainly of precipitated calcium carbonate (CaCO<sub>3</sub>). This frequently is the result of water that has a high mineral content, known as 'hard' water.

*This Technical Advisory Panel (TAP) review is based on the information available as of the date of this review. The information and advice presented to the NOSB is based on a technical evaluation is not intended to incorporate commercial availability, socio-economic impact, or any other factor that the NOSB and the USDA may want to consider in making their decisions.*

Water can be treated a number of ways before being fed into a boiler to remove calcium and other minerals responsible for scaling. Filtration, activated carbon, ion exchange, and reverse osmosis (RO) are all used by food processors to remove undesirable particles and chemicals from water. The NOSB has not addressed ion exchange for organic ingredients. Water can be deionized by filtration with either natural or synthetic substances (Helfferich, 1962). The use of synthetic resins as processing aids would appear to prohibit their direct contact with organic ingredients. However, the use of ion exchange has been reviewed by the NOSB to produce other non-organic ingredients that appear on the National List, e.g. enzymes. Pretreatment of water with ion exchange does not appear to leave any residues of incidental ingredients that would compromise organic integrity. Various colloids and chelating agents can also remove minerals from feedwater.

Water may also be chemically treated to prevent scale. Some of these are on the National List, but may not be annotated for certain uses. Among these are sodium phosphates, lignin sulfonates, sodium hydroxide, and sodium silicate. These compounds can usually be reduced to acceptable levels by precipitation (Jackson, 1987), filters, or traps. Therefore, scale treatment has generally not been considered a problem for either organic processors or certifiers. However, the chemicals used to inhibit corrosion are a significant challenge for the organic industry.

### **Corrosion: Causes and Prevention**

Most of this discussion, and the subsequent TAP reviews, will focus on corrosion and its management. Corrosion is the wear, breach, and ultimate failure of the vessel that contains the water. Corrosion will not occur in a boiler that has pure water from which all the air has been removed (Ward, 1936). Similarly, because it is a vapor and is uncontaminated by corrosive salts, steam by itself is not corrosive to stainless steel (APV Crepaco, 2000). Because food is not produced in a perfect world, these conditions never exist in a food processing facility. While corrosion can never be eliminated, various steps can be taken to reduce it. Corrosion inhibitors offer only one method of corrosion control (Nathan, 1965). A number of forms of corrosion are not chemically treated, and is addressed through design, manufacturing, and physical maintenance (Basu, Kefa, and Jestin, 2000).

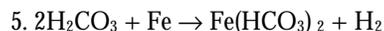
Amine-type boiler additives are used to protect steam lines and condensate systems from metal loss caused by oxygen and carbon dioxide corrosion. Corrosion results as the product of the following chemical reactions (Betz, 1980):

1.  $\text{Fe} + 2\text{H}_2\text{O} \rightarrow \text{Fe}(\text{OH})_2 + \text{H}_2$
2.  $\text{Fe}(\text{OH})_3 \rightarrow \text{Fe}^{++} + 2\text{OH}^- \rightarrow \text{Fe}_2\text{O}_3 + 3\text{H}_2\text{O}$
3.  $4\text{Fe} + 6\text{H}_2\text{O} + 3\text{O}_2 \rightarrow \text{Fe}(\text{OH})_3$

Therefore iron (steel) can corrode forming ferric oxide (rust) in boiler systems and condensate lines. A further mechanism of corrosion of boiler systems is from dissolved carbon dioxide in the water to form carbonic acid. As carbon dioxide dissolves in the water, it causes the pH to be depressed by increasing the hydrogen ion concentration according to the reaction:



The hydrogen from carbonic acid reacts with iron to form ferrous bicarbonate according to the following equation:



Carbon dioxide enters the system either as a dissolved gas or combined in alkaline components of water hardness—bicarbonate or carbonate—alkalinity of the boiler feed water. Dissolved carbon dioxide will be removed from the feedwater by a properly operated deaerating heater, but the combined carbon dioxide will remain in the feedwater. The potential for carbon dioxide corrosion in a condensate system can be reduced by lowering the alkalinity of the boiler feed water by various external treatment methods such as water softening, ion exchange, or reverse osmosis (Betz, 1980).

Additionally, oxygen can enter the boiler and condensate by direct absorption of air and by introduction with the feed water and subsequent flashing over with the steam. Depending on the plant and operations, either source could predominate. With proper mechanical deaeration and chemical oxygen scavenging all oxygen can be eliminated from boiler feed water. Good system design can minimize air contact with the condensate and subsequent oxygen absorption.

A number of chemical additives are used to treat boiler water to reduce certain production problems related to the operation of boilers. A list of FDA approved additives is contained in Appendix 1. Several of these items have

already been reviewed by the TAP, recommended by the NOSB, and listed by the NOP for use in organic food processing. These include citric acid, potassium hydroxide, and sodium hydroxide. Some are listed, but do not have annotations that do not include boiler water additives, for example lignosulfonic acid.

### **Boiler Additives**

In addition to these various approaches to reduce corrosion, most operating boiler systems use various compounds to treat or concentrate boiler water, either in the infeed water lines or in the boiler. Some of these are added to the infeed raw water; others are injected into the boiler; another use is with condensate return water. Most chemically treated corrosion can be classified according to the chemical reaction that causes it as either *acid* corrosion or *oxygen* corrosion (Kohan, 1997). *Caustic* corrosion is also a factor in a number of systems (Bradford, 1993; Basu, Kefa, and Jestin, 2000).

Acid corrosion, as the name implies, is the eating of the surface by a solution that has a pH below neutral. Various acids are responsible for this, depending on the water source. The identification and removal of the source of the acid or the addition of an alkali or caustic substance to raise the pH are the standard approaches. These function by raising the pH of the boiler water. Four commonly used substances used for such purposes are on the National List: sodium carbonate or soda ash ( $\text{Na}_2\text{CO}_3$ ); sodium hydroxide, lye or caustic soda ( $\text{NaOH}$ ); sodium bicarbonate ( $\text{NaHCO}_3$ ); and potassium hydroxide ( $\text{KOH}$ ). A fifth—ammonium hydroxide ( $\text{NH}_4\text{OH}$ )—is being petitioned. Caustic corrosion will often occur as a result of the use of these substances, and is often solved simply by discontinuing their use (Bradford, 1993).

Free oxygen ( $\text{O}_2$ ) present in water is the cause of oxygen corrosion. Oxygen can either react directly with the boiler metal and cause pitting, or it can serve as a catalyst with other elements in the water that corrode the metal (Kohan, 1997). One solution is to prevent oxygen from entering the system.

Feedwater, makeup water, and returned condensate can be physically deaerated—removal of air, including oxygen—to remove over 99% of non-condensable gases (Jackson, 1987), with some systems capable of removing oxygen to as low as 6.5 parts per billion (ppb) (Betz, 1980). The level is generally considered to result in negligible corrosion with little upkeep for most equipment (Matthews, 1951).

Some fuels are more likely to lead to oxygen corrosion than others. Replacement with a cleaner burning fuel can reduce corrosion (Payne, 1989). This more frequently reduces corrosion on the external wall that is heated (the fireside) than on the internal wall that contains the water that is heated to produce steam (the waterside). Air fed for fuel can be a source of free oxygen in the water of some systems. Low oxygen combustion—running a richer mix—can reduce oxygen found in the feedwater of these systems. However, this approach can also reduce fuel efficiency. Using a nitrogen blanket can reduce the amount of oxygen in a tube or tank that is shutdown for maintenance (Basu, Kefa, and Jestin, 2000). Naturally occurring tannins can also remove oxygen from boiler water (Matthews, 1951). Corrosion inhibitors are substances that added to the environment in which a metal corrodes. These are often metals that can be sacrificed to protect other metals (Moran and Natishan, 1993).

### **Oxygen Scavengers**

Several substances are added to water to react with free oxygen ( $\text{O}_2$ ) to remove it from suspension in water. These are known as '*oxygen scavengers*' and are generally highly reactive and volatile compounds (Kohan, 1997). The most commonly used scavenger for corrosion inhibition is sodium sulfite, usually combined with a catalyst (Schroeder, 1991). Others include ethylenediaminetetraacetic acid (EDTA) and nitroloacetic acid (NTA).

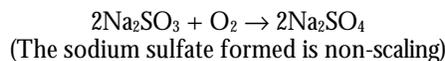
Ascorbic acid is also reportedly used as an oxygen scavenger by food processors (Bellows, 1997). Ascorbic acid used in combination with activated carbon scavenges oxygen from boiler condensate (May, 1989). Citric acid is also reportedly used. Like ascorbic acid, citric acid is not listed in 21 CFR 173.310, but is a direct food additive that is Generally Recognized As Safe (GRAS) with no limitations other than current good manufacturing practice (21 CFR 184.1033).

Corrosion is due to the following:

1. Corrosion of iron in water
2. Oxygen (dissolved oxygen in water)
3. Carbon dioxide corrosion

The rate of both boiler and condensate corrosion can be influenced by the following in-plant approaches:

1. Mechanical deaeration of the feed water is an important first step in eliminating dissolved gases such as oxygen and other corrosive gases such as ammonia, carbon dioxide and hydrogen sulfide.
2. Application of a non-volatile chemical deaerator such as sodium sulfite that is easy to handle, relatively non-toxic, and readily removed by precipitation or ion exchange. Oxygen removal takes place according to the following equation:



3. Removal of carbonate and bicarbonate components of the water by ion exchange prior to entering the boiler system.

Note that sodium sulfite has *not* been reviewed by the NOSB and that sulfites are prohibited by the Organic Foods Production Act (7 USC 6510(a)(3)). However, because it is non-volatile, there is relatively little carry over of sulfites, with excess remaining in the boiler or feedwater (Betz, 1980). Therefore, such an application would be thought of as a processing aid for a non-organic ingredient, and not in contact with the organic food itself.

#### Volatile Amines

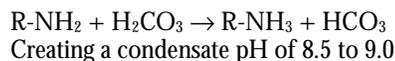
Amines are derivatives of ammonia (NH<sub>3</sub>) where a radical (R) that contains carbon replaces one or more of the hydrogen atoms (R-NH<sub>2</sub>). Amines are classified as *primary*, *secondary*, or *tertiary* depending on the number of hydrogens replaced by radicals (Streitweiser and Heathcock, 1985). These radicals may be alkanols, such as diethylaminoethanol (DEAE), cyclic hydrocarbons (cyclohexylamine), fatty acids such as stearic acid (octadecylamine), or lower aliphatic (open chain) compounds (morpholine).

Volatile amines are characterized by their high solubility in water and reactivity. These very chemical properties that make them effective as boiler water additives make them extremely difficult to remove from the steam. Therefore it is practically impossible to prevent volatile amines from coming into contact with food if those additives are being used to treat the boiler water that generates the steam. Their ability to form 'azeotropes' or solutions that have the same boiling point as water, and therefore cannot be separated by distillation makes it difficult to remove them from the steam once introduced. The petroleum industry pioneered the use of volatile amines for corrosion control in the petroleum industry in the 1940s. These compounds were adopted for use in nuclear reactors during the 1950s and 1960s (Nathan, 1965).

Early references to the initial applications of volatile amines to food processing are scarce. The introduction of volatile amines to food handling presented a number of engineering challenges. Researchers found that periodic addition caused fluctuations between undetectable and high levels. Amines that were below the detection limit indicated that the equipment was not protected from corrosion. High levels were undesirable both because it was inefficient to use excessive amounts and the residues posed a threat to food safety. Researchers found that continuously metered addition of volatile amines could maintain the carry over to relatively low levels (Malaiyandi, Thomas, and Meek, 1979). While petroleum refineries and nuclear reactors could continuously stream amines with little concern for an upper limit, food processing and hospital applications required reliable and precise injection equipment able to maintain levels at or below what was considered minimal and acceptable to protect human health.

Systems that capture and recirculate the steam are called *condensate systems*. These systems can be more energy efficient and can also conserve water. They are also considered more complicated to operate and are higher maintenance. They are particularly susceptible to oxygen corrosion. Condensate systems can be chemically treated to reduce metal loss caused by oxygen and carbon dioxide corrosion. The treatment chemicals consist of neutralizing amines, filming amines and ammonia.

Neutralizing (R-NH<sub>2</sub>) amines react with the acid (H<sup>+</sup>) generated by the solution of carbon dioxide from the condensate according to the following equation (Betz, 1980):



There are numerous amines that can be used for condensate pH neutralization and elevation. The selection of the appropriate amine is controlled by their stability and distribution ratio characteristics of the particular amine.

The distribution ratio of an amine is defined as:

$$DR = \frac{\text{amine in vapor phase}}{\text{amine in water phase (condensate)}}$$

Amines with a distribution ratio greater than 1.0 have more amine in the vapor phase than in the water phase. The distribution ratios at atmospheric pressure of FDA approved neutralizing amines are:

Morpholine-	0.4
Diethylamino ethanol-	1.7
Cyclohexylamine-	4.0
Ammonia-	10.0

(Source: Betz, 1980).

The principle advantage of volatile amines over caustics is their ability to travel the length of the steam conduction equipment. This also means that they carry over into the food. Another approach to preventing steam condensate line corrosion is the use of amines whose primary function is to create a film or coating when formulated with emulsifiers and dispersants. Filming amines provide protection from both carbon dioxide and oxygen. The major FDA approved amine for this purpose is octadecylamine. Like the other volatile amines, octadecylamine will carry over into steam that comes into contact with food.

Organic processors that use culinary steam want to protect their equipment from premature corrosion and wear. A review of the different standards and interviews with different certifiers shows that organic processors and their certifiers have responded in different ways to the NOSB's recommended prohibition on boiler chemicals in contact with organic food (NOSB, 1995). Some certifiers have required steam treated with volatile amines be required to go through 'blow down' or the removal of concentrated boiler water and solid residues from a boiler system before it can commence to process organic food by using steam generated from fresh water without additives. Blow down is an important part of any boiler maintenance program (Kohan, 1997). However, frequent starts and stops can cause wear and tear on a boiler (Montrone and Blough, 1989).

Others require that the injection system for the treatment chemicals be shut off, where possible. To clear the system of prohibited substances the processor may need to run a flush of organic product not sold as 'organic.' The interruption of treatment can also cause damage to a system (Montrone and Blough, 1989). Some organic processors have installed filters or steam traps. These in-line filters may be a minimum of 10 microns to prevent residues from boiler chemicals from entering food necessary on culinary steam lines. While these may remove mechanical carryover, they will not remove vaporous carryover.

Corrosion prevention in organic processing systems rely primarily on the installation of corrosion-resistant equipment, mechanical and physical control of factors that contribute to corrosion, and the use of additives that do not have vaporous carry over or where vaporous carry over can be removed by entrained water. Physical deaeration in combination with chemical deaeration with sodium sulfite in addition to removal of alkalinity components such as carbonate and bicarbonate may offer a short-term alternative to the use of volatile amines, provided that steps are taken to prevent carry over of sulfites. More research should be done to develop long-term sustainable alternatives.

### **Conclusion**

The TAP reviewed the neutralizing and filming amines petitioned. A review of the current state of the technology and existing organic standards supports the NOSB's recommendation for boiler water additives in Organic Good Manufacturing Practices. Residues of boiler water additives must be prevented from contacting organically produced food by the use of steam without entrained water, steam filtering, or other means. Volatile amines are made to carry over in the steam and are not practical to remove by the methods described. The TAP reviewers advised that none of the boiler water additives in that category be added to the National List. Therefore, the NOSB may want to consider amending the recommendation for Organic Good Manufacturing Practices to categorically prohibit volatile amines used as boiler water additives.

## Appendix I

### Existing Standards for Boiler Water Additives in Organic Food Processing

#### National Organic Standards Board (NOSB)

g) Boiler Water Additives (refer to 21 CFR Part 173.310(a))

"Residues of boiler water additives must be prevented from contacting organically produced food by the use of steam without entrained water, steam filtering, or other means" (NOSB, 1995).

#### Organic Crop Improvement Association (OCIA)

##### 5.2.4. CULINARY STEAM USAGE GUIDELINES

If culinary steam is used during any part of food processing, then steam condensate traps shall be placed to collect condensate for testing of known used boiler chemicals. At least one trap should be placed as close to the first entry of steam into the food system as possible.

- a. Steam filters should be required for food contact steam.
- b. Testing for the presence of prohibited substances used in boiler water conditioning shall be mandatory if culinary steam is used during any part of an organic food process and comes in contact with the food and no filters are employed to remove said substances prior to the steam contacting the food.
- c. Steam condensate testing shall be for the specific material used in that particular boiler system and should be conducted by any state of federally accredited testing facility.
- d. Limits on tested substances shall be non-detectable to the limit of the equipment used.

Recommendations:

1. All boiler systems should be on a monthly service schedule by a professional water conditioning company which tests treatment limits and operating conditions peculiar to that boiler.
2. Typical boiler operating parameters should be no more than 80% of capacity.
3. Condensate traps need to be installed at appropriate junctions to provide sampling of steam quality and purity. (OCIA, 2000).

From the OCIA list:

**Steam A** Steam in contact with food may not contain boiler chemicals and subject to the requirement of OCIA Standard 5.2.4. (OCIA, 2000).

#### Oregon Tilth Certified Organic (OTCO)

Volatile boiler chemicals--including amines such as cyclohexylamine, diethyleaminoethanol, hydrazine, and morpholine--were prohibited effective January 1, 2000 (Coody, 1998). This is consistent with their April 1999 Generic Materials List (OTCO, 1999).

#### Quality Assurance International (QAI)

(A120-99321) on the QAI website:

"7.14. Boiler Additives. Steam from boiler water, which contains additives, is not allowed to come into contact with any organic product." (QAI, 2000).

#### European Union

Organic processing must be done in such a manner as to prevent contamination or accidental substitution of organic and non-organic food products. The only processing aids permitted must appear on a closed list. Preference is given to plants and equipment dedicated to organic processing. In a non-dedicated plant, equipment is usually required to be dismantled and cleaned before an organic run when possible. Where this is not possible, the equipment is subject to a 'bleed run' (product flush) of the organic product to purge the system of residues (Michaud, Redman, and Dalby, 1994).

## Appendix II Boiler Water Additives and their Current Organic Status

<b>Substances</b>	<b>CAS #</b>	<b>FDA Limitations<sup>1</sup> / NOP Annotations<sup>2</sup></b>	<b>National List<sup>2</sup></b>
Acrylamide-sodium acrylate resin	---	Contains not more than 0.05 percent by weight of acrylamide monomer.	No
Acrylic acid/2-acrylamido-2-methyl propane sulfonic acid copolymer having a minimum weight average molecular weight of 9,900 and a minimum number average molecular weight of 5,700.	---	Total not to exceed 20 parts per million (active) in boiler feedwater.	No
Ammonium alginate	9005-34-9	----	Yes
Cobalt sulfate	10124-43-3	As catalyst	No
1-hydroxyethylidene-1,1-diphosphonic acid and its sodium and potassium salts.	2809-21-4	(CAS Reg. No.)	No
Lignosulfonic acid	8062-15-5	<i>As [a] floating agent in postharvest handling</i>	Annotated
Monobutyl ethers of polyethylene-polypropylene glycol produced by random condensation of a 1:1 mixture by weight of ethylene oxide and propylene oxide with butanol.	---	Minimum mol. wt. 1,500.	No
Poly(acrylic acid-co-hypophosphite), sodium salt produced from a 4:1 to a 16:1 mixture by weight of acrylic acid and sodium acid monomer (dry weight basis).	71050-62-9	Total not to exceed 1.5 parts per million in boiler feed water. Copolymer contains not more than 0.5 percent by weight of acrylic hypophosphite.	No
Polyethylene glycol	25322-68-3	As defined in 21 CFR 172.820	No
Polymaleic acid	26099-09-2	Total not to exceed 1 part per million in boiler feed water (calculated as the acid).	No
Polymaleic acid and its Sodium salt	30915-61-8	Total not to exceed 1 part per million in boiler feed water (calculated as the acid).	No
Sodium salt of polymaleic acid	70247-90-4	Total not to exceed 1 part per million in boiler feed water (calculated as the acid).	No
Polyoxypropylene glycol	---	Minimum mol. wt. 1,000.	No
Potassium carbonate	584-08-7	---	Yes
Potassium triphosphate	13845-36-8	---	No
Sodium acetate	127-09-3	---	No
Sodium alginate	9005-38-3	---	Yes
Sodium aluminate	1302-42-7	---	No
Sodium carbonate	497-19-8	---	Yes
Sodium carboxymethylcellulose	9004-32-4	Contains not less than 95 percent sodium carboxymethylcellulose on a dry-weight basis, with maximum substitution of 0.9 carboxymethylcellulose groups per anhydroglucose unit, and with a minimum viscosity of 15 centipoises for 2 percent by weight aqueous solution at 25 deg.C.	No
Sodium glucoheptonate	---	Less than 1 part per million cyanide in the sodium glucoheptonate.	No
Sodium hexametaphosphate	10124-56-8	<i>For use only in dairy foods.</i>	Annotated

<b>Substances</b>	<b>CAS #</b>	<b>FDA Limitations<sup>1</sup> / NOP Annotations<sup>2</sup></b>	<b>National List<sup>2</sup></b>
Sodium humate	---	---	No
Sodium hydroxide	7775-14-6	<i>Prohibited for use in lye peeling of fruits and vegetables.</i>	Annotated
Sodium lignosulfonate	8061-51-6	<i>As [a] floating agent in postharvest handling</i>	Annotated
Sodium metabisulfite	7681-57-4	---	No
Sodium metasilicate	6834-92-0	<i>See 7 CFR 205.601(l).</i>	No
Sodium nitrate	7632-00-0	---	No
Monosodium phosphate	7558-80-7	<i>For use only in dairy foods.</i>	Annotated
Trisodium phosphate	7601-54-9	<i>For use only in dairy foods.</i>	Annotated
Disodium phosphate	7558-79-4	<i>For use only in dairy foods.</i>	Annotated
Sodium polyacrylate	---	---	No
Sodium polymethacrylate	54193-36-1		No
Sodium silicate	1344-09-8	<i>As [a] floating agent in postharvest handling</i>	No
Sodium sulfate	7757-82-6	---	No
Sodium sulfite	7757-83-7	Neutral or alkaline.	No
Sodium tripolyphosphate	7758-29-4	<i>For use only in dairy foods.</i>	Annotated
Tannin	1401-55-4	Including quebracho extract.	No
Tetrasodium EDTA	64-02-8	---	No
Tetrasodium pyrophosphate	7722-88-2	<i>For use only in dairy foods.</i>	Annotated
Cyclohexylamine	108-91-8	Not to exceed 10 parts per million in steam, and excluding use of such steam in contact with milk and milk products.	No
Diethylaminoethanol	100-37-8	Not to exceed 15 parts per million in steam, and excluding use of such steam in contact with milk and milk products.	No
Hydrazine	302-01-2	Zero in steam.	No
Morpholine	110-91-8	Not to exceed 10 parts per million in steam, and excluding use of such steam in contact with milk and milk products.	No
Octadecylamine	124-30-1	Not to exceed 3 parts per million in steam, and excluding use of such steam in contact with milk and milk products.	No
Trisodium nitrilotriacetate	5064-31-3	Not to exceed 5 parts per million in boiler feedwater; not to be used where steam will be in contact with milk and milk products.	No

Sources: <sup>1</sup>21 CFR 173.310; <sup>2</sup>7 CFR 205.601(l) and 7 CFR 205.605.

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