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ספירים

סיוע לציבור, פסקי הלכה, רכיבים, מארעות ומדע
Updates for the cRc Kashrus Professional

HALACHA פסקי הלכה

Dairy Water

Chazal forbade the creation and consumption of bread which is *milchig*, e.g. made of dough which includes milk, because they were concerned that someone might inadvertently eat it with meat; the same prohibition exists for *fleishig* bread.[1] Thus, dairy bread is effectively "not kosher"[2] and may not even be eaten alone, even though all its ingredients and the equipment it was made on were kosher. The reason bread was singled out for this prohibition is that it is a staple food which is usually pareve and is used with all sorts of foods. Therefore a person is likely to forget that their particular loaf of bread is *milchig* or *fleishig*.

The early *Acharonim* debate whether this prohibition is limited to bread or should possibly include other foods which are usually pareve and commonly used at both meat and dairy meals. *Taz*,[3] *Magen Avraham*,[4] and *Yad Yehuda*,[5] hold that bread is merely an example but in truth the prohibition extends to all foods commonly eaten with both meat and milk, such as spices, wine and eggs. On the other hand, *Chavas Da'as*,[6] *Pri Chadash*,[7] and *Minchas Yaakov*[8] cite proofs that *Chazal* limited their *gezairah* to bread and argue that it is inappropriate for us to extent *gezairos* into areas not covered by *Chazal*.

The common practice among kosher certifying agencies appears to be to follow the ruling of *Chochmas Adam*,[9] *Aruch HaShulchan*,[10] and *Badei HaShulchan*[11] who accept the lenient position. For this reason, there are water,[12] orange juice, tea, margarine, and liquid egg products which are certified as kosher dairy even though they are commonly used at *fleishig* meals.[13]

INGREDIENTS רכיבים

Inorganic Raw Materials

One way that science classifies compounds is based on whether they are "organic" or "inorganic"; in this context the term organic refers to those items which contain at least one atom of carbon. Accordingly, not only are all items which come from living things (e.g. animals, food, cotton, rubber) classified as organic, but even many petroleum-based and other "synthetic" items are scientifically classified as organic. The list of inorganic items includes all types of non-living molecules (e.g. metals, sand) which do not contain carbon as well as such common items as water and salt.[14]

Although there are many foods which qualify as non-kosher, an insightful *kashrus* professional (who wishes to remain anonymous) pointed out that on the simplest level[15] every one of the non-kosher foods is organic! As such, we can tentatively suggest that all inorganic foods must be kosher. While this rule is reasonably correct, it is worth noting the following ways in which an inorganic food might be non-kosher:

– The inorganic item may contain a small percentage of an organic additive, which is

[1] *Shulchan Aruch* YD 97:1.
[2] When *Chazal* forbade the consumption of dairy bread, did they structure it as a prohibition on the food or on the person? According to the former position, an oven used to bake dairy bread would have to be *kashered* before kosher/pareve bread is baked in it, and according to the latter *kashering* would not be required. This question is discussed in *Shach* 97:2, *Pischei Teshuvah* 97:2, *Darchei Teshuvah* 97:11, and elsewhere and is beyond the scope of the current discussion.
[3] *Taz* 97:2. In order to reconcile this ruling with *Shulchan Aruch* 96:3, *Taz* suggests that if the person has a designated *fleishig* spice grinder there is no concern that the *fleishig* spices will be used for dairy, and they are therefore not forbidden. Would *Taz* grant the same leniency to one who bakes bread in an oven designated exclusively as *fleishig*? The fact that no one suggests such a leniency implies that such bread would be forbidden, which may indicate that in fact *Taz* agrees that non-bread foods are not treated as strictly as bread in regards to this halacha.
[4] *Magen Avraham* 447:45, cites and agrees with *Tzemach Tzedek* 80 (a *teshuvah* which is widely cited in regard to this halacha in *Shulchan Aruch*) at least as relates to wine in which the dairy or *chametz* was not *batel b'shishim*. *Minchas Yaakov* 60:3 suggests that *Tzemach Tzedek* might only be *machmir* on wine since wine is meant to be consumed at meat-meals. However this is questionable, as *Tzemach Tzedek* also rules that the wine is forbidden because it contains *chametz* (and therefore raises a concern that someone might drink it on *Pesach*), and clearly wine is not meant to be consumed on *Pesach*.
[5] *Yad Yehuda* 97:6 (*Aruch*).
[6] *Chavas Da'as* 97:1 (*Biurim*)
[7] *Pri Chadash* 97:1.
[8] *Minchas Yaakov* 60:3.
[9] *Chochmas Adam* 50:7.
[10] *Aruch HaShulchan* 97:2.
[11] *Badei HaShulchan* 97:1.
[12] Such water is labeled as dairy (or DE) because it is pasteurized on equipment used for fluid milk. Although there are isolated cases where this occurs, as a rule bottled water is not pasteurized, and consumers can feel comfortable purchasing bottled water even if does not bear a kosher certification symbol.
[13] There are also wines that contain *kitnios* (corn syrup) and are not certified for *Pesach*. These wines would appear to be acceptable even according to the strict opinion noted in the text, because the *kitnios* is likely *batel b'rov* in the wine.
[14] Water is H_2O and salt is NaCl, both of which are classified as inorganic, since they do not contain carbon. The air we breathe is made up of more than 99% nitrogen, oxygen, and argon, but due to the small percentage of carbon dioxide it would appear that it is classifies as organic.
[15] It is theoretically possible that an inorganic food would require *bishul Yisroel* or is forbidden because it was worshiped as *avodah zara*, but those situations are so unlikely as to be irrelevant.

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not listed on the "ingredient panel". For example, the *Poskim* discuss the propriety of drinking (inorganic) water which possibly contains (organic) bugs.

- The inorganic item may actually be a byproduct of or derived from an organic product. For example, many chemical reactions involving organic compounds create salt as a byproduct, and water vapor created as part of the concentration of milk or soup might be condensed and reused. [Both of these examples pose *kashrus* concerns within a factory which produces and then reuses these byproducts, but it is unlikely that these byproducts would be sold to other factories].
- The inorganic item might be processed on equipment which is also used for organic products.

These exceptions notwithstanding, most inorganic items are in fact kosher from any source, and the following is a list of some inorganic elements occasionally used in food production:

Aluminum, bromine, calcium, chlorine, cobalt, copper, fluorine, hydrogen, magnesium, nitrogen, oxygen, phosphorous, potassium, silicon, sodium, sulfur, and zinc

On occasion these elements will be used as-is, but in most cases these are used in food production in some sort of modified form of the element or as a compound containing two or more elements.[16] In addition to water and salt noted above, some common examples of inorganic materials used in this manner are phosphoric acid[17] and silicon dioxide.[18]

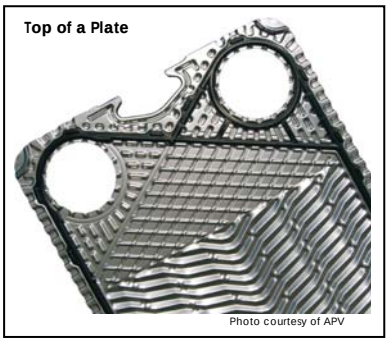
EXPERIENCE מארשת ונדע

Heat Exchanger with Regeneration

The author thanks Rabbi Moshe Heimowitz (OU) for the considerable amount of time he patiently gave on numerous occasions to help the author understand how the equipment described in this document operates, and the proper method of *kashering* it.

Heat Exchangers

A heat exchanger is a machine which allows liquids to be heated or cooled via indirect contact with the heating or cooling media. [Heat exchangers come in a number of forms; in this discussion we will limit ourselves to the most common type, plate heat exchangers, but in fact the ideas discussed apply equally to all heat exchanger types]. Briefly, a heat exchanger is made of dozens of identical, thin, rutted, stainless steel plates (shown in the picture at right) with dozens of these plates sandwiched together to create the complete heat exchanger (see second picture at right). The product and heating media flow in the thin space between one plate and the next, as follows: Product flows between plates 1 and 2, 3 and 4, 5 and 6 etc., while media flows between plates 2 and 3, 4 and 5, 6 and 7 etc., such that each plate has product on one side and media on the other. As the product and media flow through their respective areas, the heating media transfers its heat through the plate into the product.



Heat exchangers can be *kashered* relatively easily by draining any existing heating/cooling media, cleaning the heat exchanger thoroughly, waiting 24 hours, and then heating fresh water to *hag'alah* levels in the heat exchanger. This process does not pose much of a concern for typical heat exchangers and is reasonably straightforward.

Regeneration

The simple heat exchanger described above has just one function – heating product – and the product makes just one pass through the heat exchanger. For example, in the case of a heat exchanger used to pasteurize apple juice, the apple juice might enter the heat exchanger at 40° F, leave the heat exchanger at 165° F and then be bottled at that temperature.

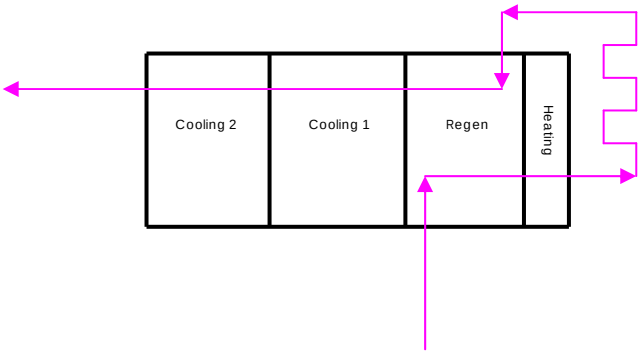
A heat exchanger with regeneration is considerably more sophisticated; it typically has two different functions – heating and cooling – and usually has 4 separate sections to accomplish those functions. For example, orange juice might

[16] See for example http://www.phosphatesfacts.org/uses.asp for a long list of food uses of phosphorous-based compounds, most of which are inorganic.
[17] "Phosphoric acid" is a broad term which includes a number of molecules which all contain varying amounts of hydrogen, phosphorous, and oxygen.
[18] The formula for silicon dioxide is SiO_2.

enter the regeneration section (described below) at 40° F where it is heated to 120° F; move to the heating section where it reaches 165° F; pass through holding tubes out of the heat exchanger; return to the other side of the regeneration section, where it cools to 80° F; and then pass through 2 cooling sections which bring it to the storage and bottling temperature of 40° F.

Aside from having both heating and cooling capabilities, the heart of the system is the regeneration section, known colloquially as the "regen", which operates as follows: Instead of having steam or hot water serve as the heating media, the cold, incoming orange juice on one side of the heat exchanger plates is heated by hot, already-pasteurized orange juice flowing on the "other" side of the plates! This efficiently serves the dual function of heating the incoming juice while simultaneously cooling the outgoing juice.

The setup of a typical heat exchanger with regeneration is shown in the accompanying diagram. The purple line shows the product starting (cold) in the regeneration section, moving to the heating section, out of the heat exchanger to the holding tubes, and then back (hot) to the "other side" of the regeneration section, and finally to the two cooling sections of the heat exchanger. [The diagram doesn't show the heating media in the heating section or the cooling media used in the cooling sections].



This type of heat exchanger might also be used in high temperature aseptic systems that require extra heating and cooling apparatuses which are respectively placed before and after the holding tubes. Those systems involve equipment which is beyond the scope of this document.

Divert valve

Another feature of this type of heat exchanger is that after the product leaves the holding tubes its temperature is measured to ascertain whether the minimum pasteurization temperature was met. If, as expected, the product is at or above the required temperature, the product continues to flow through the rest of the heat exchanger as described above, and is said to be in "forward flow". If however, the product temperature is too low, the product is diverted out of the heat exchanger so it can be pasteurized once again. When this is necessary, a valve moves to divert the product from its regular flow through divert pipes and back to the balance tank which feeds the heat exchanger; in such cases, the product is said to be in "divert flow".

The divert valve will be in one of three places – before the regeneration section, after the regeneration section, or after the cooling section. In the first case – which is by far the most common – the product will be above *yad soledes bo*, which means that if the heat exchanger ever processed non-kosher products, the divert lines, balance tank, and pipes leading from the balance tank to the heat exchanger must all be *kashered*. [It is interesting to note that these pipes and tanks are often <u>not</u> included in the start-up sterilization, as they carry non-sterile product]. In the latter two cases, the diverted product is always below *yad soledes bo*, such that the divert lines and associated piping must merely be cleaned but do not have to be *kashered*. **Thus, in order to properly *kasher* this type of heat exchanger it is crucial that the *Mashgiach* understands how its divert system works.**

Kashering Considerations

In establishing a *kashering* protocol for a heat exchanger with regeneration, one should consider the following halachic and practical factors:

Temperature

During production, the product is above *yad soledes bo* in about half of the heat exchanger,[19] but there is quite a range of temperatures; in some sections the temperature is just barely *yad soledes bo* while in others it approaches *roschin*. The letter of the law is that *hag'alah* requires water which is just above the production temperature (i.e. *k'bol'oh kach polto*),[20] but *l'chatchilah* one should always *kasher* at *roschin*.[21] Thus, if one sets the heat exchanger to a few degrees above production temperature

[19] i.e. parts of both sides of the regeneration section, the entire heating section and holding tubes. In cases where the product is diverted above *yad soledes bo* (as described below) the divert lines, balance tank, and pipes leading from the balance tank to the heat exchanger will also come in contact with product which is above *yad soledes bo*.

[20] *Shulchan Aruch* O.C. 451:5 as per *Iggeros Moshe* Y.D. I:60 and *Minchas Yitzchok* III:67.

[21] See *Darchei Moshe* Y.D. 121:7, *Pri Megadim* (M.Z.) O.C. 451:9 and *Iggeros Moshe* Y.D. I:60.

and pumps fresh water through the system, each area of the heat exchanger will usually come in contact with *hag'alah* water which is somewhat hotter than the non-kosher product was when it was at that same point. This would accomplish a valid *hag'alah*. [In a sorbet processing plant where the incoming corn syrup may be preheated to about 90° F, the *hag'alah* water would also have to be preheated in order to achieve the *k'bol'oh kach polto*]. However, we will see below that it is relatively easy to accomplish the *l'chatchilah* goal of having *roschin hag'alah* water in all parts of the equipment that require *kashering*.

Contact point

A lesser-known *kashering* requirement is that the *kashering* media must contact the utensil on the same side of the utensil that had contact with the non-kosher food. For example, if a vessel requires *libun* because it is *cheress*, one must fill the inside with coals because that is the side which came in contact with the food; it would be insufficient to surround the outside of the vessel with coals, even though the fire was on the outside of the vessel when food was cooked in the vessel.[22]

The same applies to *hag'alah*, i.e. the *hag'alah* water must come in contact with the side of the utensil which had come in contact with the non-kosher food. This halacha rarely plays a role in how one performs *hag'alah*, because *hag'alah* is usually done by submerging the utensil in *hag'alah* water or by filling and overflowing the pot or tank, in which case the *hag'alah* water is, in fact, on the side which had product-contact.

On the other hand, this halacha is quite relevant in the regeneration section of a heat exchanger. In a typical heat exchanger, if product flows between plates 1 and 2 and heating media flows between plates 2 and 3, product comes in contact with the side of plate #2 which faces plate #1 but not with the side which faces plate #3. Therefore, one may *kasher* the heat exchanger by pumping *hag'alah* water in the same route taken by the product (i.e. between plates 1 and 2). However, in a regeneration section, the heating media is itself non-kosher product, and therefore not only must the *hag'alah* water go between plates 1 and 2, but must even flow between plates 2 and 3. Furthermore, if hot product diverts back to the balance tank during production, there will be hot product between the very first raw plates after the balance tank, but unless special maneuvering is done, the *hag'alah* water on the inside of those plates will be cold, and there will only be (somewhat) hot water on the pasteurized sides of those plates.

We will see that this is also relatively simple to accomplish.

Divert lines

We've seen above that sometimes the divert lines are setup in a way which allows hot product to flow through the divert lines into the balance tank and then back to the heat exchanger, such that all of that equipment requires *kashering*.

During *kashering*, the water would never flow through the divert lines, etc., because the water is well over pasteurization temperature. In order to get the water to flow through those areas we will have to override the system and force it into "divert mode" during certain stages of the *kashering*. We will see below that using these controls it is possible to properly *kasher* these lines etc. without compromising on the other issues noted above (i.e. temperature and contact point).

Draining water

In many cases, the heating media for the heating section of the heat exchanger is water (which is in turn heated by steam in an adjacent heat exchanger). The water absorbs *b'lios* from non-kosher items processed in the heat exchanger, and to prevent those *b'lios* from returning into the future kosher product, one must either drain the water before *kashering* begins or add a *davar hapogem* to the water.

As a rule, the product is below *yad soledes bo* by the time it leaves the regeneration section, such that there are no *b'lios* into the cooling media. [Even in cases where the product will, in fact, be *yad soledes bo*, it will not be hot enough to heat the cooling media to above *yad soledes bo*, such that even in those cases there is no need to drain the cooling media].

Kashering

Note: In the coming paragraphs we will use "raw side" and "pasteurized side" to describe the two sides of the regeneration section.[23]

Kashering a heat exchanger that has regeneration and diverts from before[24] the

[22] *Shulchan Aruch* 451:1-2 (see *Mishnah Berurah* 451:9 & 17).

[23] "Raw side" refers to the side of the regeneration section which hold "raw" product which has not yet been pasteurized (and is being heated), and "pasteurized side" refers to the side of the plates which hold already-pasteurized product (which is being cooled).

[24] If the divert line is after the regeneration or cooling sections, the heat exchanger should be *kashered* like an ordinary heat exchanger except that water going into the finished-product holding tank should be directed back to the holding tank, and the loop of water should be allowed to circulate for

regeneration section, requires two stages (comprising a total of 7 steps):

– Stage 1 *kashers* the balance tank, raw side of the regeneration section, heating section, holding tubes, divert lines and the pipes back to the balance tank.

– Stage 2 *kashers* the pasteurized side of the regeneration section.

For the purposes of these instructions, we will refer to the series of illustrations of a heat exchanger with regeneration (shown at the end of this document), and use the numbers given there to refer to different parts of the equipment. The flow line which indicates the product or *hag'alah* water flowing through the system is color-coded to show temperatures as follows:

Blue = cold Yellow = lukewarm

Orange = warm Red = hot

In addition, a striped line indicates product or water flowing through divert lines.

The first two illustration are for orientation purposes; the first shows product in forward flow and the second also shows how the divert lines run.

Stage 1 of the *kashering* involves the following:

1. Drain the heating water from the heating section.
2. Turn off the pumps which control the cooling media, so that the media will be prevented from flowing through the cooling sections of the heat exchanger.
3. Fill the balance tank with water, set the heat exchanger's set point for 212° F, and begin the flow of water through the system.
4. Manually put the system into divert flow.

   In most heat exchangers there is a knob (or electronic control) where one can choose to have the system in "automatic", "forward", or "divert". The first setting is for everyday production,[25] and the latter two are overrides that the force the product or water in a specific direction.
5. Maintain this flow until the recorder for temperature probe ❹ (usually represented by the red pencil on the chart recorder) has been at *roschin* temperature for a few minutes.

At this point, *hag'alah* water which is *roschin* is flowing through the balance tank, raw side of the regeneration section, heating section, holding tubes, divert lines and the pipes back to the balance tank, and this stage of *kashering* has successfully been accomplished. **It is important to maintain this flow of *roschin* water until Stage 2 begins.**

Stage 2 of the *kashering* involves the following:

6. Switch the system into forward flow.
7. If possible, have the water flow from the finished product storage tank back to the balance tank to create a loop of water flowing through the system, and allow the hot water to flow through this loop for a few minutes.

Illustrations #3 and #4 show what happens when the system is switched into forward flow (Step #6).

– Illustration #3 shows that the first blast of water going through the pasteurized side of the regeneration section is *roschin* and the water on the raw side of that section is also still *roschin*, such that the water on the raw side does not cool off the water on the pasteurized side. This *kashers* both sides of each plate with *roschin* water coming into contact with the plate from both sides (thereby assuring that the *hag'alah* water is on the side that had food contact).

– Illustration #4 shows what happens within a few seconds of the water going into forward flow. The water on the raw side of the regeneration section is already no longer *roschin* such that it begins cooling off the water on the pasteurized side of that section. Thus, within a few seconds there is no longer a *kashering* at *roschin*, and in some portions the water will not even be hot enough for *k'bol'oh kach polto*.[26]

15 minutes after it reaches *roschin* temperatures. [This is a good idea for "regular" heat exchangers as well, and is often done as part of a standard startup at some companies]. This allows the water on both sides of the regeneration section to reach *roschin*. The *hag'alah* water at the beginning of the raw side of the regeneration section will not be *roschin* (since the water circulating back to the balance tank will be cooled somewhat by the residual cooling media in the cooling sections) but will be well above production temperature because (a) the *hag'alah* water in the balance tank will be about 100° F hotter than it is during production and (b) the *hag'alah* water on the pasteurized side of the regeneration section will be even hotter and will raise the temperature of this incoming water on the raw side.
If divert is after cooling section (last page), then balance tank never reaches *yad soledes bo* so just circulate in divert mode with cooling off (and after draining water) so as to build up temperature on both sides of the regeneration section. Balance tank and raw side of regeneration section won't get to be *roschin* (but they weren't hot) and finished side of regeneration section will be a tad below *hag'alah* temperatures due to that water on the raw side.

[25] In "automatic" mode, the temperature of the product at point ❹ determines whether the product should be in forward flow or divert flow.

[26] In most of the heat exchanger, the water will remain above *k'bol'oh kach polto*, because the heat exchanger's set point is at 212° F which is hotter than what it is set at during production. However, the water going into the balance tank will be considerably cooler than water which diverts back to the tank during divert mode. Therefore this cannot serve as a *kashering* for the balance tank and pipes leading from the balance tank to the heat exchanger.

In many cases, companies use a system very similar to the one described above for their standard startup sterilization.

Monitoring

In theory, a *Mashgiach* should be present anytime a *kashering* occurs, but in practice there are many situations when that does not occur. The *Rav HaMachshir* is forced to rely on other methods of verifying that the *kashering* took place as it was supposed to.

In the *kashering* of a heat exchanger without regeneration, the *Rav HaMachshir* will want to verify the following:

- The equipment was *aino ben yomo*.
- The water used as a heating media was drained.
- The *hag'alah* water reached *roschin* temperature.

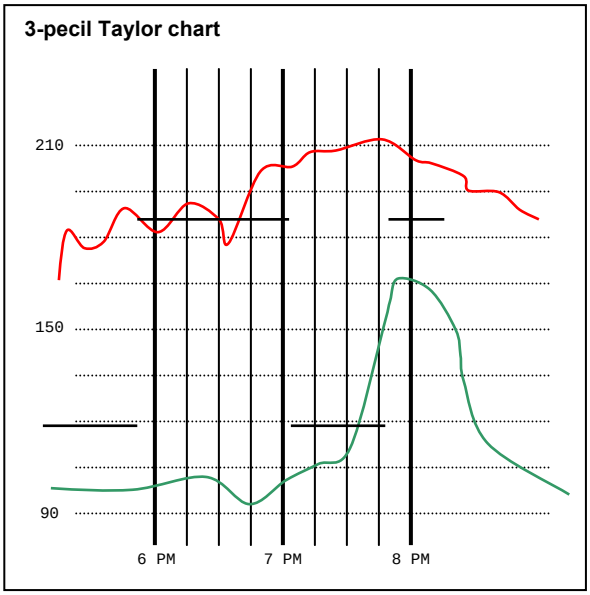
A suggestion was given at the end of *Sappirim* 10 as to how one could monitor that the heating media was drained. The other two items are monitored by checking the chart recorder, which shows that (a) no production occurred for 24 hours before *kashering* and (b) the *hag'alah* water reached *roschin*. [In fact, the chart recorder in such a heat exchanger typically just has one pencil/line, which measures the temperature at the hottest point. As such, it records that that portion was *roschin* (and that the rest was *k'bol'oh kach polto*) but cannot prove that the water was looped through the system to reach *roschin* at all parts].

In a heat exchanger with regeneration, it is somewhat more difficult to monitor that a *kashering* was done properly, but in many/most cases it is quite reasonable to do, as follows: A heat exchanger with regeneration will typically have a chart recorder that has 3 separate pencils, as shown in the accompanying chart.

- The red pencil monitors the temperature at the point just after the holding tubes ❹.
- The green pencil records the temperature at the point after the cooling sections ❼ (to make sure the product is sufficiently cool to not spoil during storage).
- A third (black) pencil indicates whether the product is in forward flow or divert flow. This pencil is different than the previous two pencils. The red and green pencil move up and down as the temperature changes, but this third pencil can only be in two positions, one for forward flow and the other for divert flow. In our example, the markings for divert flow and forward flow can be seen at about 120° F and 185° F respectively.

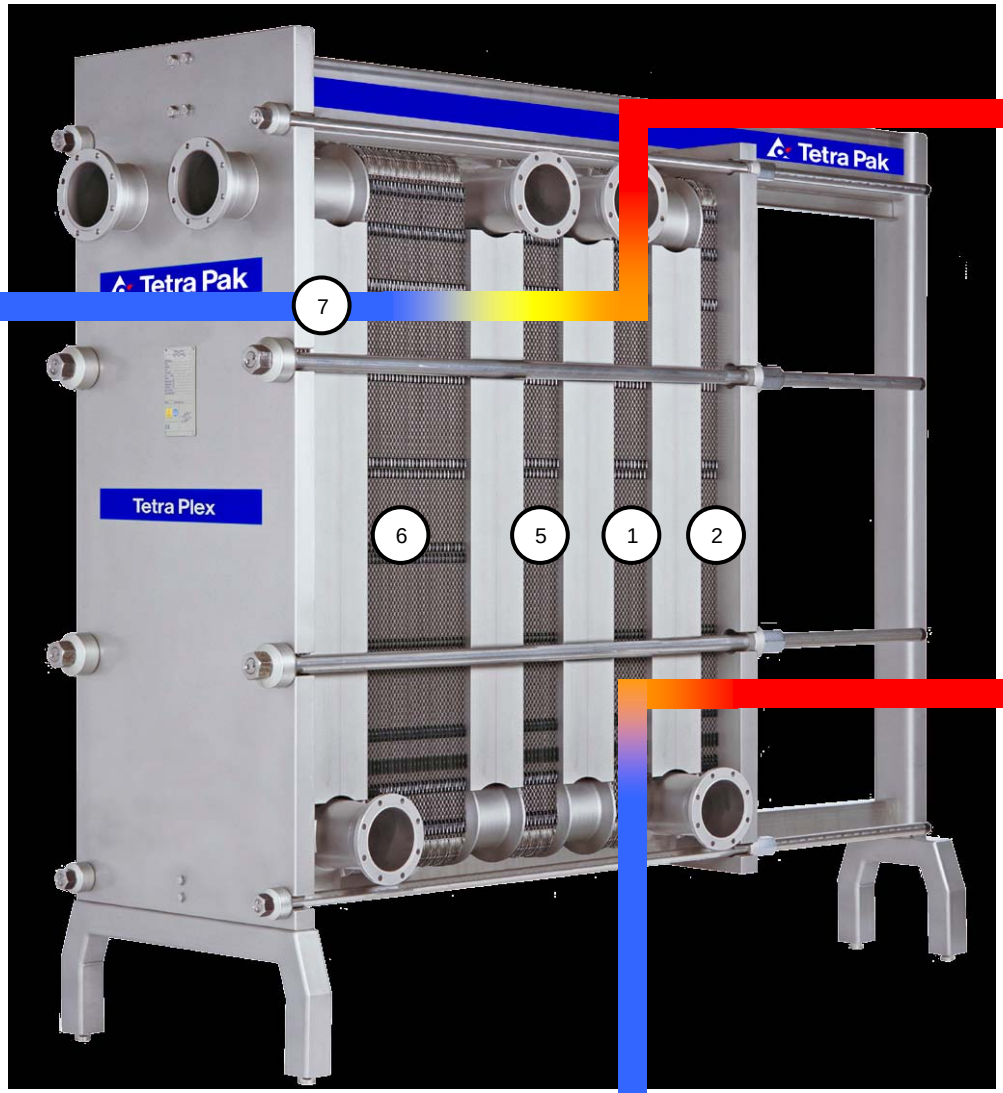
We can use these pencils to monitor reasonably well whether a proper *kashering* occurred. [The best way to know what the chart should look like after a proper *kashering* of a given system is for the *Rav HaMachshir* to actually witness a *kashering* and keep a copy of the chart recording of that event]. Here is what the chart should look like:

- During Stage #1 of the *kashering*:
  - The red pencil will be at *roschin*.
  - The green pencil will be at ambient temperature (since the *hag'alah* water has been diverted away from that temperature recorder).
  - The black pencil will indicate that the machine is in divert flow.
- During Stage #2 of the *kashering*:
  - The red pencil will be at *roschin*.
  - The green pencil will rise to a relatively high temperature (e.g. 150° F)[27] and then drop back to a much lower level.
  - The black pencil will indicate that the machine is in forward flow.



[27] The green pencil doesn't reach *roschin* because the residual cooling media sitting in the cooling plates cools them off somewhat. [The cooling section doesn't require *hag'alah* as the product is below *yad soledes bo* when it passes through there].

Heat Exchanger with regeneration
showing product in forward flow



Finished Product Storage Tank

Surge/Balance Tank

Underlying heat exchanger image is from
http://www.tetrapak.com/processingus/docs_share/C15.pdf

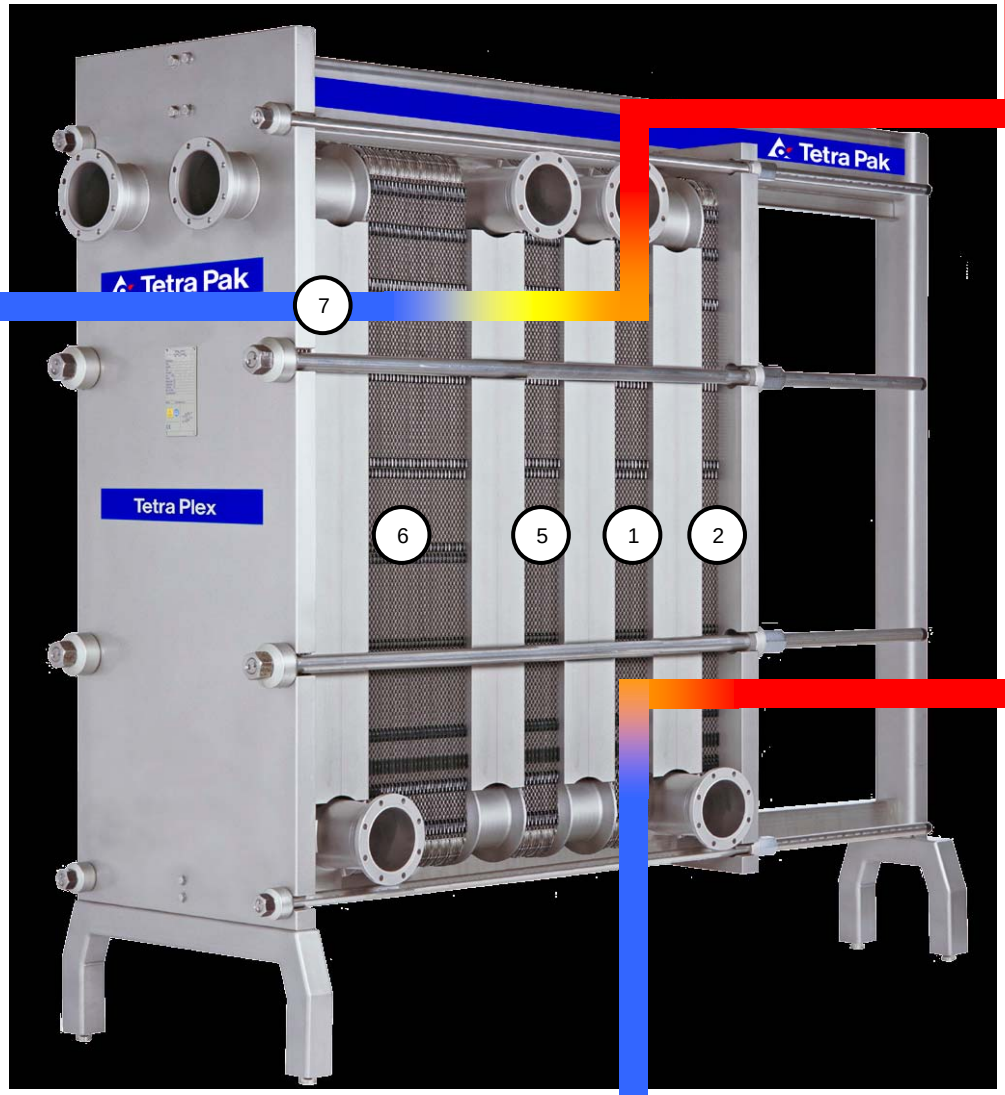
Legend

① Regeneration section
② Heating section
③ Holding tubes
④ Temperature probe (red pencil) to confirm pasteurization temperature after holding tubes
⑤ First cooling section
⑥ Final cooling section
⑦ Temperature probe (green pencil) to confirm product is cold enough for safe storage

Heat exchanger with regeneration

Illustration 1

Product in divert flow
showing divert line from 1st temperature probe



Finished Product Storage Tank

Surge/Balance Tank

4
7
6
5
1
2
3

Legend

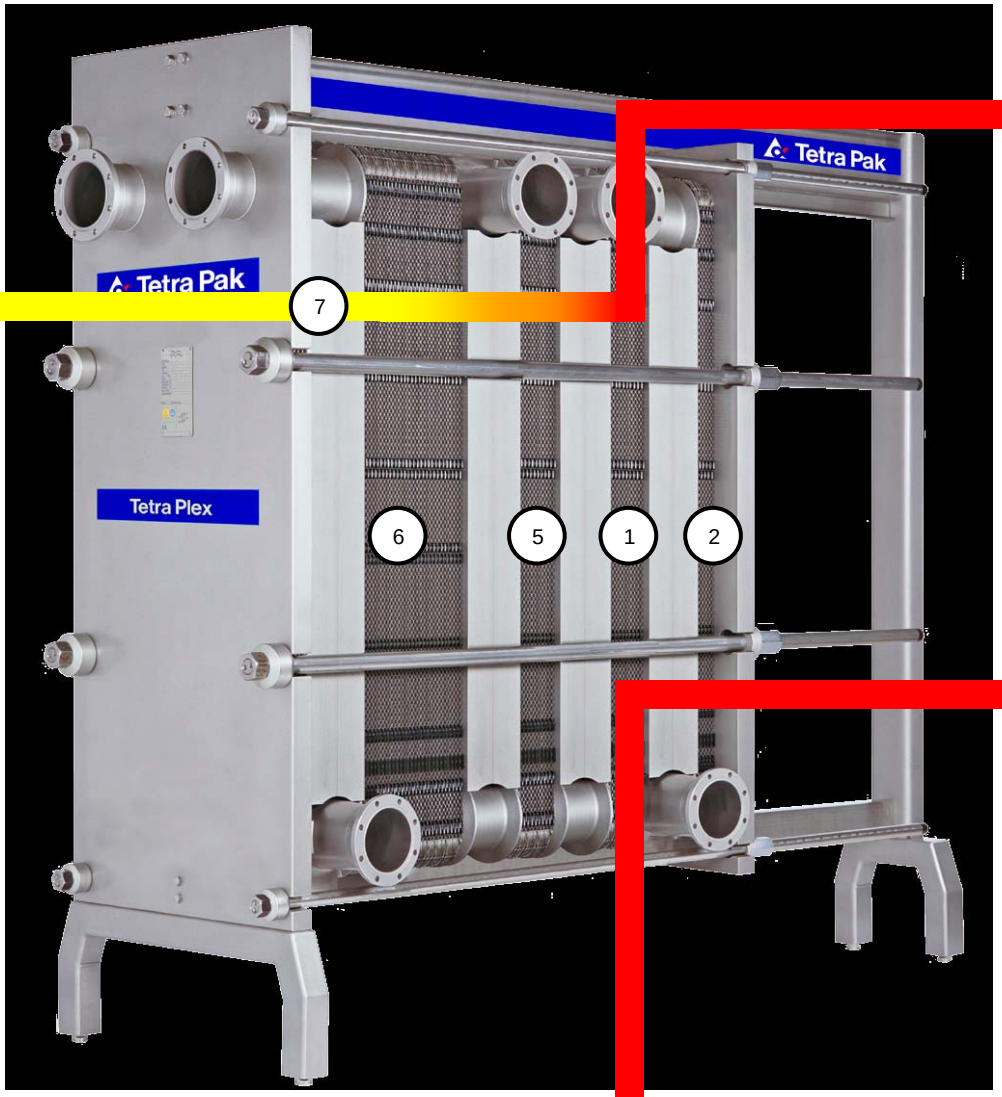
① Regeneration section
② Heating section
③ Holding tubes
④ Temperature probe (red pencil) to confirm pasteurization temperature after holding tubes
⑤ First cooling section
⑥ Final cooling section
⑦ Temperature probe (green pencil) to confirm product is cold enough for safe storage

cRc

Heat exchanger with regeneration

Illustration 2

Product in forward flow
beginning of second stage of *kashering*



Finished Product Storage Tank

Surge/Balance Tank

4
7
6
5
1
2
3

Legend

① Regeneration section
② Heating section
③ Holding tubes
④ Temperature probe (red pencil) to confirm pasteurization temperature after holding tubes
⑤ First cooling section
⑥ Final cooling section
⑦ Temperature probe (green pencil) to confirm product is cold enough for safe storage

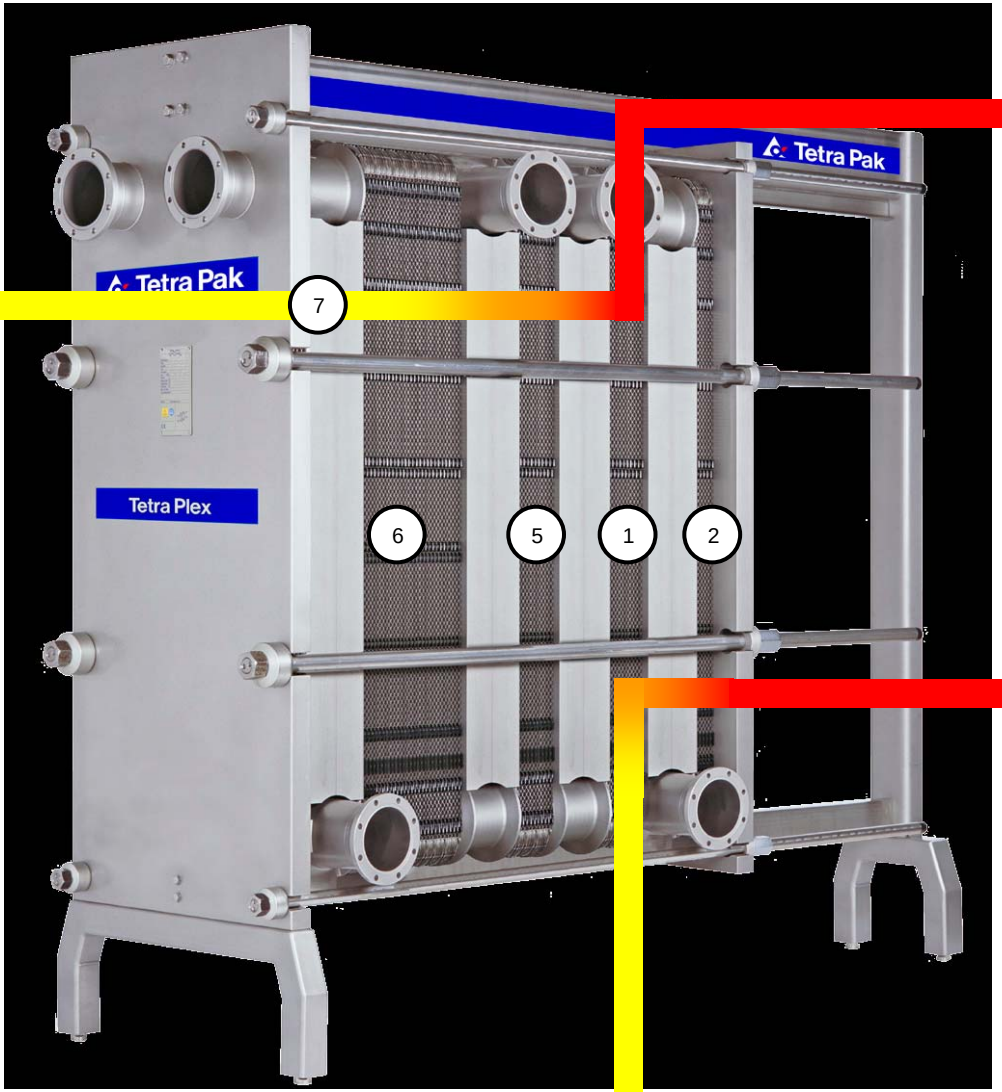
cRc

Heat exchanger with regeneration

Illustration 3

Product in forward flow

a few seconds after beginning of second stage of *kashering*



Finished Product Storage Tank

Surge/Balance Tank

Legend

① Regeneration section
② Heating section
③ Holding tubes
④ Temperature probe (red pencil) to confirm pasteurization temperature after holding tubes
⑤ First cooling section
⑥ Final cooling section
⑦ Temperature probe (green pencil) to confirm product is cold enough for safe storage

Heat exchanger with regeneration

Illustration 4