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CYANUREX®-Process for the prevention of ethyl carbamate formation in stone fruit fires

Last update 03_2009

Detailed procedural instructions according to Dr. Christoph, Würzburg

Need to limit the ethyl carbamate content in fruit brandies:

The compound ethyl carbamate - hereinafter referred to as EC - is a substance classified as germ cell mutagenic and possibly carcinogenic to humans, which can occur in fruit brandies, especially stone fruit brandies, in worrying concentrations. In Germany, several EU member states and countries outside the EU, the EC content in fruit brandies is limited to 0.4 to a maximum of 0.8 mg/l. Products with higher levels are no longer permitted. Products with higher levels are no longer marketable. Even today, more than 20 years after these guideline and measure values were set, they are still exceeded in every third stone fruit brandy.

Causes of ethyl carbamate formation:

- EC is formed from hydrocyanic acid, which is released into the mash not only from damaged but also from intact fruit stones during fermentation and mash storage.
- The hydrocyanic acid enters the spirit during distillation, whereby depending on the content in the mash and the activity of the copper surface in the still, a greater or lesser proportion of the hydrocyanic acid can be retained in the still or the stillage.
- The hydrocyanic acid that passes into the distillate can give rise to EC during the storage of the distillate. This reaction is initiated by light, but then continues on its own in the dark. The ratio is just under 1:1, i.e. 0.8 mg EC can be produced from **1 mg hydrocyanic acid.**

Prevention of EC formation:

- Reliable prevention of EC formation during the storage of fruit brandy is only possible if the hydrogen cyanide content in the brandy is limited to less than 1 mg/l.

The recommendation that the distillate should always be stored in the dark immediately after distillation, as well as later at the consumer's premises, must be regarded as cumbersome, unreliable and therefore impractical. Especially as the conversion reaction can obviously also take place in complete darkness in the presence of traces of copper.

Process for limiting the hydrogen cyanide content:

- Catalytic converter or steam washing process
- **CYANUREX®-Procedure**
- Supplementary measures according to **Annex 1**

General information and principle of the process:

- The CYANUREX®-process has been tried and tested for more than 15 years in settling and capping distilleries and is permitted under food and customs law to prevent increased EC levels in stone fruit spirits.
- By adding the special distillery additive CYANUREX®, which consists of copper salt, to the mash or to the raw spirit immediately before distilling, the copper activity in the still is increased.
- CYANUREX® binds the volatile hydrocyanic acid present or released during the distillation of stone fruit as insoluble copper hydrocyanic acid compounds (copper cyanide) and thus prevents their transfer into the distillate.
- Products distilled with CYANUREX® are free from hydrocyanic acid and the predominant part of the stone taste it causes, so that the typical character and aroma of the fruit can be fully appreciated. The benzaldehyde content, which causes the desired stone tint, remains unchanged.
- CYANUREX® does not cause any fractionation, yield or aroma losses, as it specifically binds only hydrocyanic acid or cyanides as well as sensory undesirable sulfur-containing substances.

- The required amount of CYANUREX® to be added to a distillation batch depends on various factors; in any case, the aim must be to use only as much CYANUREX® as is absolutely necessary to bind the hydrocyanic acid.
- When using the CYANUREX® process, it is essential to observe these detailed process instructions as well as the safety instructions and information on the disposal of burner residues (sludge, waste water) resulting from the use of CYANUREX®, which are summarized below.

Safety instructions for handling CYANUREX®:

- CYANUREX® is a distillery additive that is only added to the mash or the raw spirit (raw spirit) directly before distillation.
- CYANUREX® is harmful if swallowed or inhaled; contact with the skin or mucous membranes must be avoided; care must be taken to ensure that the dust is not inhaled.
- It is recommended to wear protective gloves, safety goggles and a dust mask when working with CYANUREX®.
- CYANUREX® must not get into the hands of children.
- In case of contact with skin or mucous membranes, rinse thoroughly with water. If swallowed, consult a doctor.
- CYANUREX® must be kept dry and tightly closed.

Safety instructions and application restrictions with regard to the disposal of Schlempen and Lutterwasser:

- CYANUREX® should only be used in accordance with the process instructions, whereby the guiding principle should apply: ***Use as much as necessary, as little as possible!***
- In general, distillery residues such as sludge or lutter water must not be discharged into receiving waters or into the public sewer system without a permit.
- The use of CYANUREX® can significantly increase the copper content of sludge or waste water, depending on the amount added. CYANUREX® may therefore only be used if it can be ensured that the copper content of the waste water, sewage sludge or soil does not exceed the maximum permissible levels when the distillery residues (sludge, waste water) are disposed of.
- The instructions for the disposal of sludge and sludge water when using CYANUREX® in ANNEX 3 from page 7 of the process instructions must be observed!

Procedure for different output variants:

Work equipment:

- CYANUREX®
- Rod test for estimating the content of **free or total hydrocyanic acid** in distillates in order to be able to decide on the necessity and success of cyanide-binding measures or to determine the necessary CYANUREX® dosage:
- **Schliessmann CYANIDE test** with test strips for estimating free and bound hydrocyanic acid, color comparison with a scale of 0, 1, 3, 10, 30 mg cyanide/l,
  or:
- Tube test for measurements in the critical concentration range of 1 mg/l in order to obtain more precise results, especially for a decision on the marketability of EC-free but slightly hydrogen cyanide-contaminated fires: **CYAN-EC-test** for the determination of **free or total hydrocyanic acid**, measuring range 0-0.7 mg cyanide/l in ten color gradations.
- Sample still (for the analysis and correct treatment of small batches of mash that are distilled in a single distillation batch on a booster still)
- Scales with an accuracy of at least 1 gram, letter scales if necessary
- Beaker and plastic spoon for removing and weighing in CYANUREX®
- Protective equipment: Safety goggles, protective gloves (e.g. disposable gloves) and dust mask if necessary.

1. the CYANUREX® process for double extraction and cleaning distillations:

a) Principle:

In the case of a double burn-off, the hydrogen cyanide can be completely separated due to the double contact with the copper of the burner, so that the use of the CYANUREX® process is unnecessary in this case. A decision on this can be made by determining the hydrogen cyanide content of the smoke with the **Schliessmann CYANID test**. If the hydrocyanic acid in the smoke firing is above 3 mg/l, it can be completely removed during fine firing by adding a defined amount of CYANUREX® to the smoke firing.

b) Implementation of the fine firing process:

- Distil and collect the coarse spirits from the mash as usual; ensure that the coarse spirits are already stored in the dark.
- Before fine spirit distillation, determine the prussic acid content in an average sample of the raw spirit or the collected raw spirits using the test strips of the **Schliessmann CYANID test.** If the **total hydrocyanic acid** content determined in the raw spirit is above 10 mg/l, it is recommended to carry out the determination again in a sample of the raw spirit diluted 1:1 with water and to multiply the result by 2 in order to achieve a more precise determination of the content.
- If the hydrocyanic acid content of the raw spirit is between 0 and 3 mg/l (no or only weak coloration of the test stick), the use of CYANUREX® can be dispensed with, as this content can usually be bound by the available copper in the still during fine distillation.
- A CYANUREX® additive is recommended for levels above 3 mg/l. The necessary requirement is calculated from
  - the hydrogen cyanide content of the smoke,
  - the volume of the rough spirit batch for fine spirit distillation and
  - an empirical factor of 1.5

  according to the following calculation formula:

  CYANUREX®-Requirements (g) = Hydrocyanic acid content (mg/l) x Volume (hl) x 1,5

  Example:
  Hydrocyanic acid content of the smoke 10 mg/l Volume of the preparation: 1hl
  CYANUREX® requirement = 10 x 1 x 1.5 = 15 g
- Weigh out the required amount of CYANUREX® on a scale and add it to the raw spirit immediately before distilling in the still.
  Distil the fine spirit as usual, separating **sufficient pre-distillation and after-distillation.**
- Separate the afterburn at the latest at 50 % vol in the receiver, discard or collect and later fine-burn again separately, but **do not add** to the next roughened spirit under any circumstances: Any EC that may be present in the roughened spirit is **completely** enriched in the afterburn of the fine spirit.
- The completeness of the hydrogen cyanide separation should be checked in a sample of the middle run of the fine spirit obtained, diluted to drinking strength, using the **Schliessmann CYANID test** or the **CYAN-EC test**.

c) Carrying out the process when re-distilling distillates with or without an intensifier (purification distillation):

Distillates and non-marketable spirits that are to be **reburned due to hydrogen cyanide** and / or **EC contamination must be diluted with water to approx. 30-35 % vol.** before purification distillation. After complete mixing of the material, the total hydrogen cyanide content must then be determined in an average sample using the **Schliessmann CYANIDE test**.
The CYANUREX® requirement is then calculated and the cleaning firing is carried out as described above at ☞ **1.b) (fine firing)**.
Here, too, care must be taken to ensure that the afterburner is separated as early as possible in order to remove any EC that may have already formed. It is also essential that sufficient pre-combustion separation is carried out during subsequent firings in order to remove any EC-containing tailings remaining in the column.

2. the CYANUREX® process for one-off removal (distilleries with reinforcing trays):

a) Determination of the optimum CYANUREX® additive:

The optimum addition of CYANUREX® during the single distillation of stone fruit mashes depends on the hydrocyanic acid content of the mash and the hydrocyanic acid-binding copper activity of the still. If the mash contains more hydrocyanic acid than can be bound in the still, CYANUREX® must be added to the mash to be distilled directly before distillation.

- If a small batch of mash is distilled in a single distillation process, CYANUREX® can only be added if the hydrocyanic acid content is known. This requires the prior trial distillation of an average mash sample and the estimation of the **free hydrocyanic acid** in the sample distillate using the **Schliessmann CYANIDE test**. ☞ **2.b)**

- If a large, homogeneously mixed batch of mash is mashed in several runs, the amount of CYANUREX® added to the mash of the subsequent spirit is reduced or increased depending on the hydrocyanic acid content of the previous spirit already produced with CYANUREX® added. This requires the estimation of the **free hydrocyanic acid** in the middle run of the preceding spirit using the **Schliessmann CYANIDE test**.☞ **2.c)**

b) Distillation of small mash batches after determination of the CYANUREX® requirement by sample distillation

Appendix 2 describes the procedure for determining the CYANUREX® requirement by sample distillation. The expected cyanide content of the distillate and thus the approximate CYANUREX® requirement can be determined by distilling a mash sample in a standard laboratory sample distillation unit, which can also be used to determine the alcohol yield.

- for the necessary CYANUREX® requirement from **Table 2, Appendix 2**,
- Weigh the required amount of CYANUREX® on a scale and add it to the mash to be distilled immediately before distilling in the still.
- Burn off the mash as usual, separating off sufficient pre and post run-off, reason: pre run-off can contain residues of EC-containing post run-off from the previous firing still remaining in the column. Any **EC already present in the mash is completely enriched** in the after-run if the switch from medium to after-run is made at 50% vol in the receiver at the latest.
  Discard or collect the overruns and distil again later, **but never add** to the next mash.
- The completeness of the hydrogen cyanide separation should be checked in a sample of the middle run of the fine spirit obtained, diluted to drinking strength, using the **Schliessmann CYANID test** or the **CYAN-EC test**.

c) Distillation of large mash batches with adjustment of the CYANUREX® dosage according to the hydrocyanic acid content of the previous hydrocyanic acid content of the previous spirit:

- If no sample distillation is carried out according to 2.b), the first distillation batch of a larger homogeneously mixed mash batch is to be distilled with a **flat-rate CYANUREX® addition of 15 g/hl,**
- Also observe the instructions given under 2.b) for fractionating the distillate,
- use the **Schliessmann CYANID test** to measure the level of **free hydrocyanic acid** in the middle section,
- Maintain or correct the CYANUREX® addition to the next distillation batch on the basis of the measurement result according to **Table 1**.

Table 1: Increase or decrease of the CYANUREX® additive in the subsequent firing according to the blue acid content of the first or previous firing:

Hydrocyanic acid content (mg/l)	Coloring of the test stick	CYANUREX® addition to the next distillation batch
0	no coloring	reduce by 5 g/hl
1	faint violet	Maintain or increase by 3-5 g/hl if necessary
3	clearly violet	increase by 5-10 g/hl
10	strong violet	increase by 10-15 g/hl

Appendix 1:

General possibilities for reducing the content of hydrocyanic acid or EC in stone fruit distillates:

To reduce the hydrocyanic acid and EC content in the distillate, additional measures should be taken in advance to reduce the amount of CYANUREX® still required for complete hydrocyanic acid removal during distillation.

a) Possibilities for reducing the hydrocyanic acid content of the mash:

- Process stone fruit with a low stone content and high sugar content under conditions of maximum quality (pure yeast, acidification, enzymatic mash liquefaction, ...),
- Pass through stone fruit,
- Avoid damaging the stones during mashing,
- cool, shortest possible storage of fermented mashes until distillation,
- Note that higher hydrocyanic acid contents are to be expected, especially in distillates from mash batches with a high stone content (e.g. last distillation of a large mash batch that was not homogeneously mixed).

b) Reduction of hydrogen cyanide by activating the burner:

- Clean the firing device frequently, especially when firing stone fruit, so that all copper surfaces are bright. Copper surfaces that are covered, tarnished or otherwise soiled cannot bind hydrocyanic acid.
- Measuring the hydrogen cyanide content in each fire using the **Schliessmann CYANID test** provides reliable information on how the hydrogen cyanide-binding activity of the burner is reduced by contamination in subsequent fires.

c) Reduction of the EC content during firing:

- Small amounts of EC are already produced during fermentation and distillation; however, this EC can be produced in the aftermath,
  that means by separating the overrun in good time (at 50% vol. in the receiver at the latest).
- It is essential to avoid the common practice in some distilleries of adding after-runs of previous brandies to the mashes or rough spirits before distillation, as this carries the risk of EC enrichment.
- Instead, collect the overruns separately and later subject them to a separate cleaning firing, whereby the overrun must be separated and discarded very early on.
- Note that EC can also enter a distillate via the feed, as any residual components from the previous firing, which may be present in the trays, the column head and the cooler, are transferred with the feed.
  Therefore, always ensure that there is sufficient flow separation!

d) Reduction of the EC content when storing distillates that are not completely free of hydrocyanic acid:

In principle, fresh distillates that are slightly contaminated with hydrocyanic acid (converted to drinking strength max. 1 mg/l), but whose marketability is to be maintained by blending with hydrocyanic acid-free distillates instead of re-distilling, must be stored in the dark immediately after distillation.

Appendix 2:

Determination of the CYANUREX® requirement via the hydrocyanic acid content of a sample distillate:

a) Principle:
Fermented mashes cannot be tested directly for hydrocyanic acid using the **Schliessmann CYANID test.**
In this case, it is necessary to distil a sample of the mash on a laboratory scale and measure the **free hydrocyanic acid** in the distillate obtained. The approximate CYANUREX® requirement for the actual distillation of the mash can then be calculated from the measurement result.

b) Work equipment:

- Sample still with accessories
- **Schliessmann CYANID-test** oder **CYAN-EC-test**

c) Durchführung (weitere Hinweise s. auch unser Infoblatt „ Bestimmung des Alkoholgehaltes in Wein, Most, Maische (Probedestillation)“:

- Take about 1 liter of mash (average sample with stones) from a mash batch,
- Pour 200 ml of the sample into the distillation flask of the apparatus via the measuring cylinder,
- Add 200 ml of water while rinsing the measuring cylinder,
- Add boiling stones and silicone antifoam solution,
- Add approx. 5 ml of water to the sample (80 ml volumetric flask with marker),
- Start distillation slowly (ensure sufficient cooling and tightness of the apparatus),
- Distil slowly until the mark on the 80 ml volumetric flask is almost reached,
- Mix the distillate well and determine the hydrocyanic acid content using the **Schliessmann CYANIDE test**,
- Take the CYANUREX® requirement from Table 2 and calculate it based on the volume of the distillation batch.

Table 2: Determination of the CYANUREX® requirement for distilling a small batch of mash in a single run-off from the hydrocyanic acid content of the distillate obtained by sample distillation:

Hydrocyanic acid content in the distillate CYAN-EC test (mg/l)	Hydrocyanic acid content in distillate Schliessmann CYANID test (mg/l)	CYANUREX® requirements (g/hl)*
0	0	0
0-1	1	5
2-5	3	10
6-10	3-10	15
11-20	10-30	20
>20	30	20-30

*If necessary, adjust the CYANUREX® additive for the following fires according to the instructions for the CYANUREX® procedure (see 2.c), Table 1)

Appendix 3:

Instructions for the disposal of waste water and waste when using the CYANUREX® process:

Please note!!!

The environmentally sound disposal of waste and waste water in food-producing companies such as distilleries is subject to the applicable federal, state and municipal regulations, whereby the applicable statutory regulations must be observed.The disposal of distillery residues (sludge, waste water and cleaning liquors from the distillation equipment) must be carried out in a manner permitted by water and waste legislation. Discharge into the public sewage system (indirect discharge) and discharge into receiving waters such as rivers, lakes, etc. (direct discharge) is not permitted without a permit. In this respect, there are usually only the following options for the disposal of burner residues:

- agricultural utilization by spreading on agricultural land
- a delivery to a wastewater treatment plant suitable for further processing
- disposal in landfills

The following provides an overview of the options and legal provisions for the disposal of waste water and residues in wastewater treatment and capping distilleries, particularly with regard to possible increased copper contents. However, this compilation does not claim to be complete or legally binding.

1. regulations for disposal by direct or indirect discharge:

For all distilleries that wish to discharge their wastewater into the public sewer system, the corresponding discharge conditions of the sewer statutes of the respective municipality apply; these have been virtually the same for all municipalities since 1996. The following conditions, among others, must be observed when discharging wastewater into the public sewer system:

pH-value:	6,5 - 9,5
Temperature:	<35°C
Copper content:	<1,0 mg/l

Particularly in view of the fact that slops as well as waste and cleaning water from fruit distilleries generally **do not** meet these requirements, **the discharge of distillery residues without pre-treatment into the public sewage system must generally be regarded as impermissible, unless this is expressly permitted by the responsible municipality or the wastewater authority.**

2. disposal of distillery residues in sewage treatment plants:

Many capping and settlement distilleries can dispose of their distillery residues, especially the stillage, via specially equipped reception stations at municipal sewage treatment plants. In the catchment area of capping distilleries, there are efficient sewage treatment plants that can dispose of distillery residues in an appropriate manner and convert them into sewage sludge. After separation of solids, the wastewater/stillage mixture is neutralized there with caustic soda or lime and processed in the sewage treatment plant's digestion tower. One acceptance criterion for the disposal of the sludge via the sewage treatment plants is the concentration of copper - measured in mg copper/kg dry substance - in accordance with the specifications of the Sewage Sludge Ordinance.
If distillery residues are discharged to wastewater treatment plants, the wastewater treatment plant operator must be made aware of the possibility of increased copper contents, whereby an examination of the residues may be necessary if CYANUREX® is used. If necessary, however, an approximate indication of the quantities of CYANUREX® used or the resulting copper concentrations according to the calculation given under point 5 is sufficient. The sewage treatment plant operator must then decide to what extent the sewage sludge, with which the distillery residues are mixed, can continue to be used for agricultural purposes in accordance with the criteria of the Sewage Sludge Ordinance. The copper-contaminated cleaning liquor from a catalytic converter or the lutter water from a CYANUREX®-fired rougher burn can also lead to increased copper values and thus disposal problems when added to the stillage.

3. decoppering of lutter water and cleaning liquors in large-scale operation - the FLUTEX® process:

Provided that large quantities of wastewater are processed collectively, the FLUTEX® process offers the possibility of economically removing copper from wastewater and cleaning liquors. The resulting copper-free wastewater can then be discharged directly into the sewage system. Copper-containing sludge, on the other hand, cannot be easily decoppered as a large proportion of the copper is bound to the solids.

The principle of the FLUTEX® process is the precipitation of copper from the largely solids-free wastewater using the flocculant FLUTEX® in a treatment reactor with an agitator. The copper-containing flocs that precipitate as sludge are separated from the supernatant, decoppered wastewater by sedimentation, further dewatered in a filter press and disposed of or recycled by smelting. The user acquires the right to use this process and to later purchase FLUTEX® by paying a one-off license fee of around € 2500. Further one-off costs of around twice this amount are incurred for the necessary approval procedure with the responsible supervisory authority, including advice on the dimensioning and practical operation of the plant.

Detailed information on the FLUTEX® procedure is available at: J. Stetzer, Ingenieurbüro für Umwelttechnik und Analytik, Kapellenweg 8, 66606 St. Wendel, Tel: 06851/80077-30, Fax -31, www.stetzer.de

4. temporary storage/collection of distillery residues:

Burner residues can be fed into closed pits or collection containers without a drain. In any case, any existing connections to the sewage system or to bodies of water must be closed. If immediate agricultural utilization is possible, collection may be dispensed with. As sludge tends to decompose more quickly by acid fermentation due to its ingredients, whereby e.g. hydrogen sulphide and other unpleasant odors can be produced from the protein, it is recommended to increase its pH value to pH 8-10, e.g. by adding lime.

5. spreading on agricultural land:

According to Annex 1 List 1 of the Biowaste Ordinance of 21.9.1998, "waste from the distillation of spirits such as fruit, grain and potato stillage" and "sludge from the distillery (alcohol distillery)" is considered biowaste, which may also be applied to permanent grassland as part of a mixture. Notwithstanding fertilizer regulations, no more than 20 tons of biowaste (dry matter) per hectare may be applied within 3 years. As further, more detailed regulations must be observed in individual federal states are to be observed in individual federal states, it is recommended in any case to inquire about the current status of the regional regulations at the responsible agricultural or district offices or the regional laboratories for wastewater and soil testing.

Limiting the copper content of biowaste and agricultural soils:
When waste is spread on agricultural land, there are restrictions regarding the heavy metal content of the soil as well as the biowaste, whereby in the case of burner residues, attention must be paid to the maximum copper content, **which must be below 100 mg/kg dry matter of the material to be spread. When using the CYANUREX® process, this limit value is usually exceeded, so that the copper content of the soil must be known before application.**

Knowledge/testing of the copper content of agricultural soils before application:
The copper content of most soils is generally very low compared to other heavy metals. Soils with copper contents of less than 5 mg/kg dry matter (DM) are considered to be undersupplied. Soils with contents between 5 and 9 mg/kg are medium, those up to 20 mg/kg are high or optimally supplied. At concentrations above 30 mg/kg dry matter, the soil is already oversupplied, with light soils (sandy soils) being oversupplied from 20 mg/kg. On heavily aerated, coarse sandy soils and on freshly cultivated moors, for example, there is often a copper deficiency, so that this often has to be improved as part of a fertilization plan by applying up to 5 kg of copper fertilizer (e.g. copper sulphate, special copper oxides, copper slag) per hectare. Copper deficiency also occurs particularly in soils with higher pH values and in dry conditions. In this respect, such soils would be suitable for the application of distillery residues with higher copper contents. Soils from older vineyards or hop plants, on the other hand, are usually oversupplied with copper as a result of copper spraying - burner residues should generally not be applied here.
According to § 9 of the Biowaste Ordinance, certain soil values for heavy metals, in particular copper, must not be exceeded. A limit value of 60 mg applies to the application of biowaste on clay soils, 40 mg for clay soils and 20 mg for sandy soils, in each case per kg of dry soil substance.
According to Section 4 (3) of the Biowaste Ordinance, distillery waste with an expected copper content of more than 100 mg/kg dry matter may only be spread after the residues have been tested and approved by the competent authorities.

However, if soils with relatively low copper contents or even copper deficiencies are available for the application of distillery residues with elevated copper contents, there should be nothing to prevent a corresponding permit. The distillery residues with a known copper content can then be applied to the relevant areas as part of a fertilization plan if the copper content of the soil is known.

6. calculation of the copper content of distillery residues:

As already mentioned above, when using the CYANUREX® process it is important to know or determine the copper content of the burner residues for proper disposal at a later date. The following options are available for this purpose:

- For individual batches: Calculation of the approximate copper content based on the known CYANUREX® dosage and the known quantities of distillery residues.
- When collecting the waste and waste water: Keep a **record** of the quantities of CYANUREX® used and the quantities of distilled mashes and raw spirits or their slops and lutter water as well as the cleaning liquors of the distillation equipment; calculate the approximate copper content based on the known CYANUREX® dosage and the known volumes of all collected distillery residues (see below).
- Most accurate method: Analysis of the copper content of an average sample of the collected residues in a commercial laboratory or in the wastewater treatment plant, whereby the copper content is determined in the dry substance.

Estimation of the copper content in collected distillery residues when using CYANUREX®:
The approximate copper content of the slops of mashes distilled with CYANUREX® can be calculated as follows with regard to disposal after collection as well as immediate application to agricultural land or delivery to the sewage treatment plant:

Copper (mg/Liter Slop) = g(CY) x 7,7 : V + 10
Copper (mg/kg Dry matter) = Copper content mg/l x 100 : Solids content (%)

with:

G(cy) = Use of grams of CYANUREX® for distilling mashes
Factor 7,7 = zFor conversion to stillage and copper
V = Volume of all collected mashes in hectoliters
Correction factor 10 = approximate normal copper abrasion mg/l during firing
Factor for calculation on dry matter (mg/kg dry matter) = usually 5,
corresponding to 20% solids content

Example of a compensation distillery:
Firing with booster and CYANUREX®, collection of the stillages from
4 stone fruit mashes, distilled with the addition of 12 g CYANUREX® each, 120
liters each; 8 pome fruit mashes, distilled without CYANUREX®, 120 liters each

Total CYANUREX® additive: 48 g
Total volume: 14.4 hl
Copper content of the stillage = 48 x 7.7 : 14.4 + 10 = approx. 46 mg copper/liter stillage
Copper content (mg/kg TS) = 46 x 5 = 230 mg copper/ kg TS

If the sludge is mixed with waste water or other waste water, the solids content can be reduced accordingly. The copper content is increased in particular by the cleaning liquors, whereby 100 liters of the cleaning liquor from a combustion plant or from a catalyst can correspond to a copper input of up to 40 g, which must be included in the above calculation.

Example of spreading on agricultural land:
If, for example, a distiller applies slops of mash to a 1000 m2 orchard with a soil copper content of less than 2 mg/ kg (copper undersupply), which was distilled with a total of 500 g CYANUREX®, the copper content of the soil would increase by approx. 1 mg/kg after application, provided that the slop is distributed in the topsoil to a depth of approx. 30 cm (1 ha topsoil corresponds to approx. 3 million kg).
An optimum supply of copper to the soil (10 mg/kg) is therefore only achieved if 0.5 kg of CYANUREX® is applied with slops every 8 years. The copper increase is further reduced to two-thirds to one-half by tillage or incorporation into deeper layers. Corresponding calculations can also be applied with regard to the disposal of copper-containing cleaning solutions.

Note:

It is recommended to have the copper content of agricultural land determined by local water and soil laboratories or agricultural offices; the costs for such tests are relatively low.