Tankguard Flexline – Hot Cure Guideline

INTRODUCTION

Besides having the correct choice of coating, the successful in-service performance of a tank coating system strongly depends not only on the standards of surface preparation and paint application, but also on the conditions and degree of curing of the applied system.

The purpose of this document is to provide additional information, regarding the methodology of the hot curing required for the Tankguard Flexline system. This document is not a step-by-step procedure, but is intended as a practical tool / guide to assist in the planning, execution and monitoring of the hot curing process.

In order to achieve its optimal in-service performance capabilities, it is required for Tankguard Flexline to be hot cured prior to exposure to any cargo.

1. HOT CURING METHODS

There are several different methods of hot curing of cargo tank coatings, prior to loading any cargoes.

- Hot seawater / freshwater curing by immersion
- Hot seawater / freshwater curing with tank cleaning system
- Hot curing with hot air

As some methods are more practical or more efficient than others, selection of the most suitable method for a specific project should be based on the actual conditions on site, structural design and size of cargo tanks, as well as availability of heating equipment on site (i.e. heating coils, on-deck heat exchangers, external heaters etc.).

To achieve a successful hot curing of a tank coating system, it is critical that the entire surface is heated up to the required minimum temperature for the specified period of time.

Below are listed the current, most commonly used methods:

1.1. Hot seawater/freshwater curing by immersion

A hot cure may be achieved by filling up the cargo tanks with hot seawater or hot freshwater. Tanks should be filled-up to maximum capacity, in order to ensure that the entire tank coated surface (including the deckhead) has attained the minimum required temperature.

Before beginning of the hot curing process, the applied coating system must be sufficiently cured to allow immersion. The time required for this initial curing will depend on the temperatures and further information can be found in the relevant Product Data Sheet.

The time required to achieve the hot cure will depend on the capacity of the employed heating equipment, ambient temperatures, the temperature of the coated substrate, as well as the condition of the areas adjacent to the tank (i.e. water ballast tanks, cargo tanks, void spaces etc.).

The table below provides information about the minimum required curing time in relation to the internal tank substrate temperature.

Coated substrate temperature (°C)	Minimum curing time (hours)
60 °C	16 hrs
65 °C	10 hrs
70 °C	6 hrs
75 °C	4 hrs
80 °C	3 hrs

Notes:

1) *Starting (heating-up) time to achieve the required temperatures is not included in the minimum curing times stated in the above table, as it will depend on the capacity of the employed heating equipment, the external temperatures and the condition of the adjacent areas (i.e. water ballast tanks, cargo tanks, voids etc.).*

2) *Under no circumstances shall the temperature of the curing medium (water) exceed 80°C.*

3) *The water temperature must be monitored continuously during the hot curing process, using the available onboard internal cargo tank temperature measuring systems.*

   Measuring the substrate temperature of the adjacent areas (i.e. main deck, or other accessible areas), by using a suitable temperature measuring equipment is also recommended, in order to confirm that the entire tank substrate is sufficiently hot cured.

4) *It is critical that adequate records of the temperatures are maintained throughout the hot curing process, to ensure that the entire coated substrate has attained the minimum required temperature, for the specified period of time.*

There are several ways of raising and holding the temperature of the water at the required level, and below is the most commonly used method:

Heating water in slop tanks

- Water in the slop tanks is heated up to the required temperature by using the slop tanks' heating coils.
- The hot water from the slop tanks is circulated to the cargo tanks being hot cured. Enough water should be heated up to ensure that the entire area of the cargo tanks is immersed.
- Normally, cargo tanks are hot cured in pairs to speed up the hot curing process and reduce the loss of heat.
- The temperature of the water in the cargo tanks subject to hot cure should be maintained at the required temperature throughout the hot curing process. This can be achieved by:
  - *Using the cargo tank heating coils*
  - *Re-circulating back through the heated slop tanks*
  - *Re-circulating through heat exchangers installed on the deck*
- The temperature of the water should be continuously monitored throughout the hot cure period using the cargo tanks' internal probes available on board. The steel temperature of the immersed cargo tanks being cured will be related to the water temperature. However, measuring the steel temperature of critical areas (on bulkheads and deckhead), using properly calibrated instruments (i.e. contact or IR thermometer) is recommended.

  The surface temperature could be measured using data logger equipment although, based on experience this is not essential for this method.
- The time and surface temperature readings for each cargo tank being hot cured must be accurately logged and the records made available to JOTUN for evaluation.
- Once a pair of tanks are hot cured, the hot water is transferred to the next two tanks to be hot cured. In this way, reheating of water with ambient temperature can be prevented. This process should be repeated until all tanks are hot cured.

Other methods of heating water are also appropriate, including heating the water in the individual cargo tanks, by using the cargo tanks' heating coils (if available), the heat exchangers available on board, or by using external heaters if necessary. Selection will be based on the capacity of the available ship's equipment, ambient temperatures and the time required to complete the hot curing process.

1.2. Hot seawater/freshwater curing with tank cleaning system

A hot cure may also be achieved by circulating hot seawater or hot freshwater, using the vessel's tank cleaning equipment and the available cargo heating system (i.e. cargo tanks' heating coils, on-deck heat exchangers etc., or other suitable external heating equipment).

The temperature of the water circulated through the tank cleaning equipment shall not be higher than 80°C, whereas the required minimum substrate temperature of the internal cargo tank surface must be 60°C.

Before starting the hot curing process, the applied coating system must be sufficiently cured to allow immersion. The time required for this initial curing will depend on the temperatures, and further information can be found in the relevant Product Data Sheet.

The time required to achieve the hot cure will depend on the capacity of the heating equipment used, ambient temperatures, the temperature of the coated substrate, as well as the condition of the adjacent areas (i.e. water ballast tanks, cargo tanks, void spaces etc.).

The table below provides information about the minimum required curing time in relation to the internal tank substrate temperature.

Coated substrate temperature (°C)	Minimum curing time (hours)
60 °C	16 hrs
65 °C	10 hrs
70 °C	6 hrs
75 °C	4 hrs
80 °C	3hrs

It is recommended that prior to starting the hot water circulation through the tank cleaning equipment, the water is heated up to a temperature of 80°C, using the heating coils in slop tanks, or by other suitable heating equipment (i.e. onboard heat exchangers, or other external heaters). Then, the hot water should be circulated through the tank cleaning system (butterworth machines) continuously, for the minimum required time as outlined in the above table.

Notes:

1) *Starting (heating-up) time to achieve the required temperatures is not included in the minimum curing times stated in the above table, as it will depend on the capacity of the employed heating equipment, the external temperatures and the condition of the adjacent areas (i.e. water ballast tanks, cargo tanks, voids etc.).*

2) *Under no circumstances shall the temperature of the curing medium (water) exceed 80°C.*

3) *The temperature of the circulating hot water (inlet and outlet water), must be monitored continuously during the hot curing process, using the available onboard temperature measuring systems.*

   Measuring the substrate temperature of the adjacent areas (i.e. main deck, or other accessible areas), by using a suitable temperature measuring equipment, is also recommended, in order to confirm that the entire tank substrate is sufficiently hot cured.

4) *It is critical that adequate records of the temperatures are maintained during the entire hot curing process, to ensure that the entire coated substrate has attained the minimum required temperature, for the specified period of time.*

1.3. Hot curing with hot air

A hot cure may also be achieved by circulating clean hot dry air into cargo tanks using hot air burners. It requires specific air heating installations and more sophisticated surface temperature measuring equipment. Normally, the hot curing with hot air will need to be carried out and certified by a qualified sub-contractor. This method is more complex (more expensive) and require specialised heating equipment, and therefore it is not included in this guideline.

However, if decided to follow this method, the ship owners and/or shipyard should contact a qualified sub-contractor that is specialised in carrying out such hot curing and authorised to certify the hot cure of the cargo tanks, based on the above temperature requirements.

2. REFERENCES

The hot cure methods listed above are well accepted and commonly used in the marine coatings industry. Each method will require different resources and planning, therefore selecting the most suitable method for specific project will depend on the actual conditions on site, and the decision should be based on the following criteria:

2.1. Hot seawater / freshwater curing by immersion

- Relatively easy to execute using the available onboard equipment.
- The method ensures that the entire tank surface attains the required temperature.
- Easy to monitor the water temperatures using the cargo tank internal measuring systems available onboard, though additional surface temperature measurement equipment is also recommended.
- The hot curing process can be executed at the yard and/or when the vessel is in service (on voyage to first cargo).

2.2. Hot seawater / freshwater curing using the tank cleaning system

- Relatively easy to execute using the available onboard equipment.
- It will require more comprehensive monitoring to ensure that the entire tank surface attains the required temperature.
- The hot curing process can be executed at the yard and/or when the vessel is in service (on voyage to first cargo).

2.3. Hot curing with hot air

- Relatively complex (more expensive) method that would require the use of specialised equipment and qualified sub-contractor.
- Sophisticated substrate temperature measuring equipment is required.
- The hot curing process can be executed only at the yard.

3. Important Notes

3.1. Hot curing methods described above, are suitable for vessels with double-hull design only.

3.2. To ensure effective hot curing and avoid blistering due to 'cold wall effect', the adjacent areas (i.e. water ballast tanks, cargo tanks etc.), must be empty, or in case of cargo tanks, contain a cargo with a temperature close to the intended hot curing temperature, but not higher than the maximum allowed temperature for hot curing 80°C.

3.3. The selected method of hot curing should be agreed upfront between the owner / management company and the shipyard and be a part of the contractual agreement. This, in order to prevent any misunderstanding and unnecessary arguments later on, as well as, to help in having proper planning of the hot curing process and required resources.

4. CONSIDERATIONS

The proper hot curing of Tankguard Flexline is critical for achieving the optimal in-service performance capabilities of the tank coating system. Therefore, the following must be taken into account, during the preparation and execution of the hot curing process.

4.1. Size and structural design of cargo tanks

In case of hot curing method 1.2. (hot seawater/freshwater with tank cleaning system), it is very important to check and confirm that the tanks' structure and cleaning equipment are designed to allow the entire tank substrate to be reached and heated up to the required temperature for the required length of time.

It should be clear that bigger tanks will require longer initial (pre-heating) time and more heating power (equipment with bigger capacity), in order to reach and maintain the minimum required temperature for the required length of time.

4.2. Required equipment

Normally, using the onboard cargo tank cleaning equipment (butterworth machines), in combination with the cargo heating system on board (i.e. cargo tanks' heating coils, heat exchangers etc.), should be sufficient to achieve the required temperature at normal ambient conditions. However, the size of the tanks, capacity of the equipment, the condition of the adjacent areas (i.e. voids, water ballast, cargo tanks, etc.), and the outside temperatures are critical factors that should be taken in consideration. If the available onboard equipment is insufficient, or for whatever reason, it cannot be used, then additional/external heating equipment should be employed in order to achieve the required conditions.

4.3. Heating coils

If the cargo tanks are equipped with heating coils, these are normally used to assist the hot curing process. If the hot curing is carried out when the vessel is afloat, it is required that the water ballast tanks adjacent to the cargo tanks where the hot curing is in progress, are empty. Otherwise, the applied coating system might be affected by blistering due to 'cold wall effect'. Depending on the actual conditions and ambient temperatures, it might be necessary to supply hot air into the adjacent areas (i.e. voids, water ballast tanks etc.), in order to assist the hot curing process.

4.4. Weather conditions

As the weather conditions (air temperatures) will have a direct effect on the temperature of the coated substrate (especially on cargo tanks' deckhead), it is advisable to carry out the hot curing of the cargo tank coating system at favourable (warm) weather conditions. In case of the hot curing has to be carried out during winter (cold) conditions, the following precautions should be considered:

- Insulate all single plated areas of the cargo tanks (i.e. deckhead) with appropriate thermo-blankets, mats or other suitable material.
- Supply hot air to the adjacent water ballast tanks and void spaces in order to prevent cooling down of the cargo tank steel substrate by the cold air in these areas.
- If necessary consider covering the main deck with vinyl sheets, or other suitable covering material, and supply hot air into the void created between the cover and the deck.

4.5. Monitoring & temperature control

It is important to ensure that the entire cargo tanks' coated substrate has been heated up to the required temperature for the required length of time, and therefore monitoring and recording of the temperatures is essential. As entering the cargo tanks during the hot cure is unsafe, it is recommended to use special devices (i.e. data-loggers), so that the actual temperature of the tank substrate (bulkheads, deckhead and tanktop), can be checked and confirmed.

Another key parameter to monitor is the temperature of the inlet and outlet hot water circulated through the tank cleaning equipment (butterworth machines) and the heating system (heating coils and heat exchangers) during hot curing for each tank. As a basic rule, the temperature of the water discharged from the tank should not be lower than the minimum required temperature as defined in the specific hot curing method (referring to hot curing methods described in 1.1. and 1.2.).

Where possible and required, a qualified JOTUN Coating Advisor should be made available to attend the project, in order to observe / monitor the hot curing process.

Note: It is not the role of the Jotun Coating Advisor to approve the hot curing process, they are present to observe/ monitor and offer advice when requested.

5. GENERAL NOTES

5.1. Considering all above, it should be clear that the hot curing of cargo tank coating is a complex process and it requires good understanding and preparation. Hot curing during winter conditions could be very difficult and time consuming and the risk of having insufficiently cured spots (areas of cold pockets) is very high. As it would be very difficult to identify those areas, it is strongly recommended to avoid (whenever possible) carrying out hot curing at cold winter conditions.

5.2. In order to have an objective assessment whether the hot curing has been successfully completed, all actual temperatures and times for each cargo tank should be adequately monitored and recorded.

5.3. In cases where the surface temperature measuring equipment is unavailable or insufficient, and/or the access to the adjacent areas to the cargo tanks is limited, the temperature of the inlet and outlet water can be used as (alternative) indication of the surface temperature of the cargo tanks. However, it is very important that all other precautions as stated here above are observed and sufficient number of temperature readings of the accessible areas are taken (i.e. main deck, stools etc.), in order to allow an objective conclusion whether the subject cargo tank is successfully hot cured.

The information provided in this document is to the best of our knowledge and experience correct and given in good faith. It is not intended to be exhaustive, but to provide general guidance, as well as, to point out some of the critical factors influencing the hot curing process.