Product Installation Guideline & Maintenance Document

1. General Specifications

GHT radiators and coolers are designed and sized to meet specific heat rejection loads while operating within specified steady state flow rates, temperatures, pressures, fluids/gases, altitude and ambient conditions. A GHT Cooling System Data Sheet (CDS) can be provided which specifies the operating parameters for each cooler. Refer to the following link for the Terms, Conditions and Warranty:

https://www.f-e-t.com/tc-completions

2. Product Serialization

GHT radiator systems which package multiple coolers, will have a Primary Serial Plate located on the frame which identifies the unit serial number, manufacture date and part number of the finished unit. Each cooler will also have a Cooler Serial Plate located on the cooler tank which specifies the maximum allowable working pressure and temperature rating, manufacture date, part number and serial number for the cooler. DO NOT remove any of the serial plates from the product as this will void any warranty claims and limit GHT's ability to conduct any product quality investigation. If reporting any quality issue or requesting information about the product to GHT, provide clear photos of these serial plates and or reference the information on them.

Primary Serial Plate

Cooler Serial Plate

3. Product Labels & Warnings

Some GHT product may come equipped with standard ISO danger, warning and caution labels. GHT does not recommend removing, painting or covering any of these labels or tags and the customer assumes all risk if the labels are removed or covered. Example labels are shown below (but not limited to):

4. Product Quality Inspection

All GHT product undergoes a final visual quality inspection prior to shipment which includes a review for:

- Defects in workmanship
- Damaged or non-conforming parts
- Product appearance
- Order completeness

In process inspections verify:

- Torque of critical bolted joints
- Fan/motor and/or belt alignment and belt tension
- Fan vs shroud placement
- Cooler leak testing via air and/or hydro pressure testing

GHT suppliers conduct fan balancing and motor testing to verify function and performance. GHT does not conduct any “hot” or system testing of its final assembled products.

Upon receipt of the product, contact GHT immediately if there are any missing or damaged parts. Remove caps and plugs and visually inspect for signs of large debris, corrosion or rust. Minor damage to the cooling fins can be resolved by gently bending them back straight but for any severe dents a cooler leak test may be required to determine a course of action. Hose clamps, while tightened in the factory, may leak and require additional tightening during initial heat cycling.

5. Product Transport & Storage Guidelines

When moving a radiator the following should be considered:

- Lift the unit on an appropriately rated pallet using the appropriate equipment
- Use lifting points on the unit as identified by GHT
- DO NOT lift coolers via any welded rock guard flanges
- Use appropriately rated hardware and procedures to lift radiators or coolers
- Lift unit slowly and level to prevent shock, twisting or dropping
- DO NOT use sling angles less than 45° when lifting.

For storage, less than 6 months the following should be followed:

- Store indoors and in dry area that has a constant temperature to avoid:
  - Formation of condensation which may cause corrosion
  - DO NOT allow condensation to form, collect and freeze inside a cooler, tank, lines/tubes or fittings as this will cause failure and void warranty'
- Drain all coolant or other fluids and store when dry
- Ensure all caps are installed and sealed to prevent ingress of water or debris
- Non-metallic components such as grommets, rubber mounts and foam seals can dry out and crack if exposed to direct sunlight in dry hot conditions
- GHT does not recommend storing radiator packages outdoors due to high humidity or sudden and severe temperature changes that may result in corrosion and/or damage that is not covered under warranty. Consult GHT document GMS-004 if outdoor storage is necessary
- Assembled units should be stored on flat level ground to prevent the weight of the unit causing any permanent deformation or damage of:
  - Cooler to frame seals or gaskets
  - Cooler gasketed or grommeted seal joints
  - Fan misalignment
  - Excessive wear on fan belts or fan motor bearings

For storage between 6-24 months the following should also be followed:

- Inspect for corrosion from condensation and flush appropriate coolers with either glycol or oil and reseal all openings with plastic caps or plugs
- Consult GHT representative for long-term storage considerations

For storage greater than 24 months the following should be followed:

- The appropriate coolers and tanks should be completely filled with either glycol or oil, resealed and capped or plugged
- Repeat procedure every 24 months in storage
- Consult GHT representative for long-term storage considerations

6. Product Installation Guidelines to Maximize Performance

To obtain the maximum performance of the cooling system the following design parameters should be carefully considered. Failure to consider these parameters during the design, sizing, selection and placement of the cooling system will result in decreased or inadequate cooling performance.

- Full or partial enclosure installation must consider:
  - Required ventilation area via openings, louvers or ducting to provide ability to exhaust hot air and replenish with fresh cool air
  - Influence screens, louvers, filters, sand guards or adjacent obstructions will have on airflow restriction vs the fans static pressure performance
  - Effect of cooler inlet air being preheated due to heat sources in the enclosure
  - Recirculation of hot cooler exhaust air mixing with the inlet air supply
  - Coolers must be placed a minimum of no less than one fan diameter (recommended 1.5x) within any obstructions which may include but is not limited to walls, tanks, machinery, ductwork and large piping

- Outdoor installation must consider:
  - Cooler protection from thermal shock and over pressurization during startup and operation in conditions below 60F (15C) must be considered
    - See guidelines for thermal and pressure durability protection in Section 7
  - Standard TEFC motors are enclosed and provide protection from normal weather but motors should be shielded from direct jets of water
  - Motors must have the proper insulation ratings suitable for operation in their intended ambient environments
  - Ensure adequate drainage exists to prevent moisture from freezing in the radiator low points

- General Performance considerations:
  - Operation should always remain within the Cooling System Data Sheet parameters specified by GHT
  - Fouling and Cleaning
    - Environments with particulates, debris or oil/fluid droplets within the airflow will require regular cleaning maintenance
    - ALL the coolers fin surface area requires cleaning
  - Cooler Installation
    - Mount cooler(s) in the orientation specified by GHT
    - Circulate fluid(s) through the cooler(s) as specified by GHT
    - Properly seal around shroud, ducting or housing to minimize potential airflow leakage around cooler(s)
  - Plumbing Circuitry
    - Operate within the intended steady state flow rates
    - Minimize bends, elbows and restrictions to reduce static pressure drop

        - Piping/Line diameter should match the port or fitting connections
    - Expansion/Surge Tanks
        - Should located as the highest point in the system
        - Requires a vent line from the highest point back to the tank if any piping/lines are run above the tank height
        - A drain valve should be installed in the lowest point of the system
    - Fan Performance
        - Fan airflow intake and exhaust surface areas should each be sized 1.5x the fan surface area
        - Do not reverse fan direction or orientation
        - Power source must match the motor nameplate
        - Electrical installations must be completed by certified electrician and comply with local codes
        - Hydraulic ports must be connected to obtain proper fan direction
        - Adjust hydraulic supply flowrate and pressure to obtain required fan speed
        - Ensure belt driven systems have correct belt tension to maintain desired fan speed while under peak load without slippage

7. Product Installation Guidelines to Maximize Durability

To obtain the maximum durability of the cooling system the following design parameters should be carefully considered. Failure to consider these parameters during the design integration and maintenance of the cooling system could result in instantaneous or premature failure.

- Piping and/or Hoses
    - Avoid long runs that are only supported by the connection to the radiator
    - Should be independently supported per standard pipe fitting practices
    - Highly recommended that all inlet and outlet cooler connections be made via a flexible vibration dampening connection

- Fan Control Strategy
    - Avoid excessive cycling and/or rapid starting/stopping of the fan to prevent fatigue resulting from vibration to the coolers, fan and structures
    - Consider operating parameters such as variable fan speed controls and starting temperatures to minimize thermal shock to coolers (particularly brazed aluminum bar and plate coolers) when operating in temperatures below 60F (15C)

- Radiator Mounting
    - Recommend utilization of elastomeric isolation mounts to minimize vibration input when mounting units to any subframe that has an operational excitation frequency (ex: engine, pump, compressor)

  - Over constrained coolers may fatigue due to thermal expansion

- Corrosion Protection
  - Verify fluid(s) & gas(es) are compatible with the cooler material and seals
  - Periodically inspect for scale or corrosion build up inside tanks, lines and cores
  - Periodically inspect for corrosion on frames and reapply coatings as needed

- Cleaning
  - Detergents/degreasers must be compatible with the cooler and seal materials. Consult GHT for compatibility prior to cleaning.
  - Use caution when using compressed air or pressure washers to avoid fin damage
  - Spray direction should be parallel with fin profile to avoid damage
  - Keep fan blades clean to reduce dirt buildup to prevent unbalance and vibration and do not clean with abrasives

- Thermal Shock (Brazed Aluminum Bar & Plate Coolers)
  - Rapid changes in cooler temperature due to a sudden influx of large volumes of hot fluid can cause premature fatigue. This phenomenon is exacerbated where there the differential between the initial cooler temperature and entering fluid temperature is high. Thermostats that suddenly switch from fully closed to fully open should be avoided.
    - It has been observed that thermostats may not gradually or properly open as intended as they age or are operated in sub-zero conditions
  - Coolers should not experience a delta temperature increase greater than 6^{o}F/min (4^{o}C/min) from ambient (cold) conditions to steady state operating (hot) conditions in less than a 30 minute warmup period
  - Coolers should not experience a cooldown rate greater than 140F (60C) in less than a 60minute period

- Pressure Fatigue or Over Pressurization
  - Coolers must not exceed the rated pressure AND be protected at the inlet from excessive pressure resulting from (but not limited to):
    - High fluid viscosity due to cold temperature
    - High frequency pressure spikes
    - Rapid flow changes
    - Downstream blockages
  - Selection of a pressure protection device should consider:
    - Pressure relief setting, valve type, orientation and location
    - Flow rates and ambient and fluid temperature conditions
    - Reaction time sensitivity in various ambient temperatures
  - Reliance on upstream relief valves with complex or long runs of piping prior to the cooler may not provide adequate pressure relief protection in the cooler

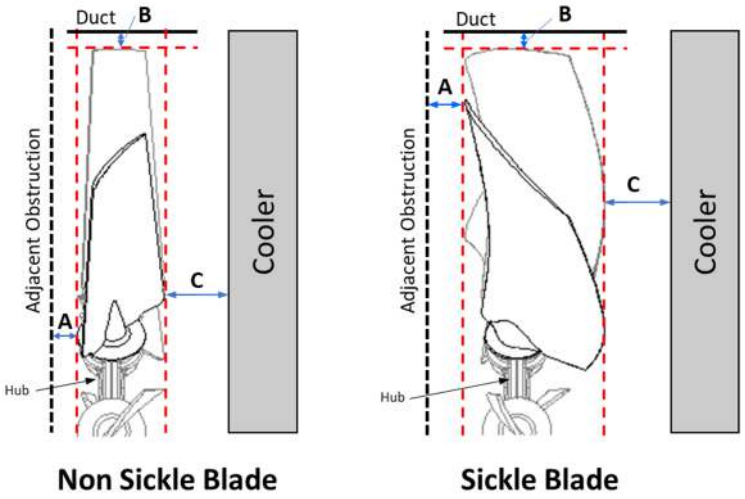
- Integration of diverting or mixing thermostatic valves for use as protection or warming strategies must be carefully considered when used with Brazed Aluminum Bar & Plate coolers
  - In either configuration (mixing or diverting), flow will take the path of least resistance which is through the valve resulting in little to no flow through the cooler. Once the "B" port of the valve fully closes, flow will have no path but through the cooler which can result in two potential failure modes:
    - ***Pressure fatigue/rupture:*** cold (high viscous) fluid in the cooler will restrict the flow of hot (low viscous) fluid causing the internal cooler pressure to increase
    - ***Thermal Shock fatigue:*** high flow rates of a hot fluid entering a cold cooler over short period of time will cause thermal shock to the cooler. Thermal shock causes temporary high localized stresses because of different rates of thermal expansion between thick and thin components. It is greatest at inlet of a cooler.

- Condensation Freezing
  - Conditions where a gas will be cooled below the dew point will form condensation and if the cooler is operating in temperatures below 32F (0C) the condensation may freeze and cause significant cooler damage
  - Allow for all condensation to drain from inside the cooler core, tanks, lines and fittings to prevent accumulation and freezing

8. Fan Installation Guidelines

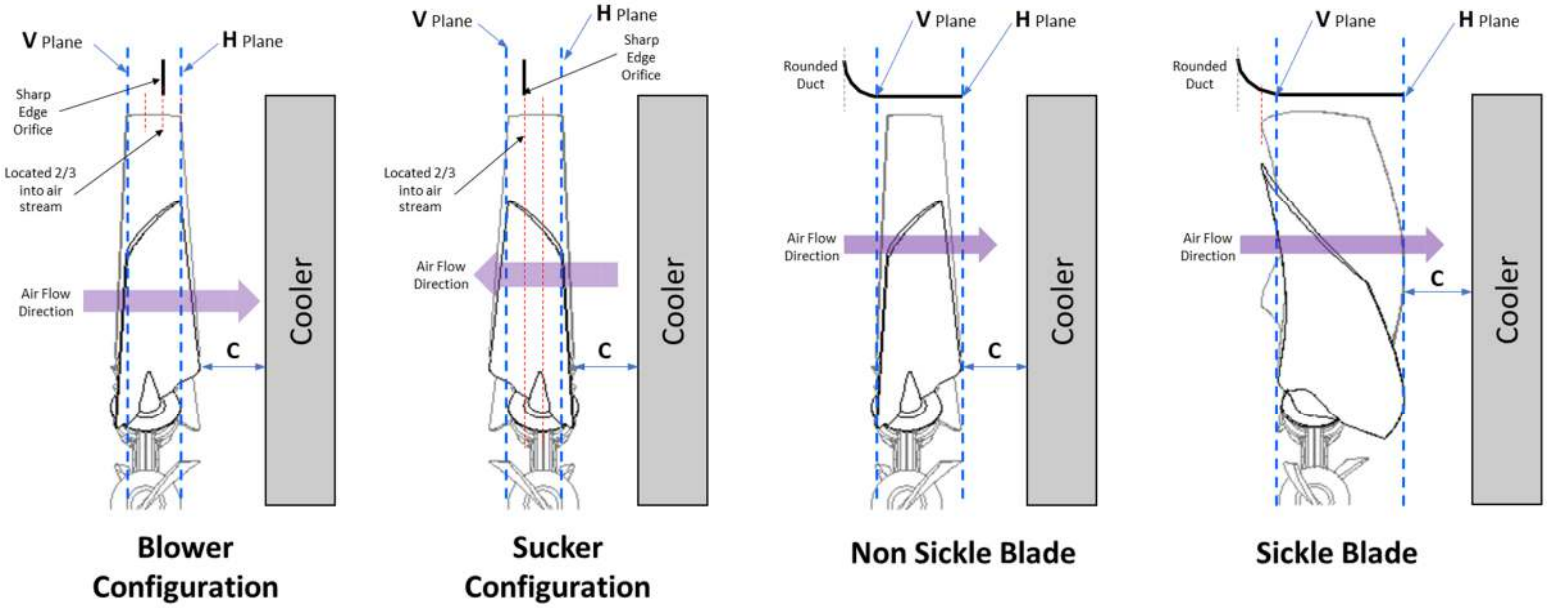
Customers that are installing the fan should follow these guidelines for fan placement relative to the cooler, shroud, ducting and guards. Refer to the appropriate guideline for the correct type of fan blade (sickle or non- sickle) profile. Contact GHT if there are any special considerations, concerns or questions.

- Fan Clearance Minimums
  - "**A**" Clearance of 1" from blade edge to any adjacent obstruction (guard, etc)
  - "**B**" Tip clearance
    - 3/8" for Fan OD <= 48"
    - 1/2" for Fan OD > 48"
  - Clearance 1/2" from fan hub to any obstruction with the exception of the fan hub / bushing to motor

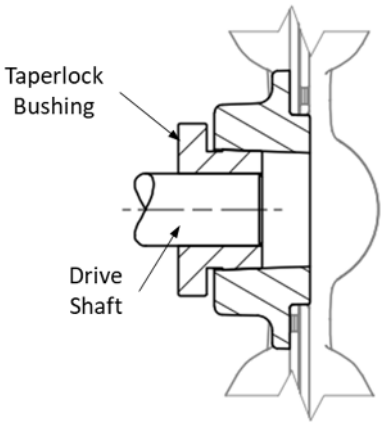


- Fan Placement Minimums from Cooler
  - "**C**" for shallow installations "**C**" = Fan OD x 0.1 from core face in above image
  - Greater distances will allow the development of a better airflow stream
  - DO NOT install closer than 4"

- Shroud/Duct Placement
  - Sharp Edged Orifice
    - Fan blade tip extends 2/3 of its profile depth into the air draw side of orifice
    - Orifice location may be extended via the use of a duct
  - Rounded Orifice Duct
    - **Non-Sickle Blade** – Duct should be located with duct bottom edge flush with fan H or V plane, whichever is appropriate for airflow direction
    - **Sickle Blade** – Duct should be located with duct bottom edge flush to fan extent, whichever is appropriate for airflow direction
    - *"H Plane" is maximum distance from hub midplane to blade trailing edge*
    - *"V Plane" is distance from hub midplane to base of blade leading edge*
    - *Sickle Blade type is when the blade tip axially extends past the blade base*
  - Fan duct placement does not require adjustment for fan tip deflection



- Fan Shaft Mounting
  - Motor shaft should go through the full length of the bushing if possible
  - Where not possible, shaft shall be inserted no less than 1.5x shaft diameter into the bushing or hub
  - Ensure the key is located under the set screw
  - Where possible mount engine such that end of fan driving shaft is flush with far end of taperlock bushing



9. Startup Checks

Following all the necessary safety protocols as defined by the customer the following is a minimum checklist to perform prior to initial startup and during the initial operation:

- Slowly and carefully spin the fan blade by hand to verify proper clearance
- Ensure all guards, covers and shrouds are securely installed
- Ensure radiator is securely attached to the frame, skid or structure
- Verify electrical connections and breakers are properly installed
- Check that all connections are tight and not leaking
- Check for proper coolant levels and fluid quantities
- Check cleanliness of cooling surface

- Check for any airflow restrictions
- Check belt and sheaves are properly aligned and belts are properly tensioned
- Verify there is no air entrapment in the system
- Verify that the required airflow requirements are achieved
- Verify the inlet and outlet airflow temperatures and fluids are within specification

10. Product Maintenance

The following are basic guidelines for general maintenance and care for a radiator.

- Pillow Block & Motor Bearings
  - Lubricate or grease per the manufacture's guidelines
  - DO NOT over lubricate or grease
  - Verify any plugs have been reinstalled, are tight and there are no leaks

- Belt & Pully Drive Systems
  - Belt tension is unique to each belt manufacture and installation
  - Refer to belt manufacture's guidelines for tensioning value and procedure
  - Over tensioning belts will reduce belt and bearing life
  - Check for loose belts as cooling performance can be degraded
  - Optimal tension will prevent belts slipping when fan is under peak load
  - Check belt and sheave alignment after any service or maintenance activity
  - Poorly aligned belts can result in reduced belt or bearing life
  - Replace worn, frayed or damaged belts

- Radiator Frameworks, Structures & Guards
  - Inspect for any loose bolts or hardware with special attention to:
    - Cooler mounting
    - Guard and shroud mounting
    - Framework connections, cross braces, braces and hatches
  - Inspect for any cracks at welds or main members with special attention to:
    - Motor mounting structure/brackets
    - Framework support structures and cross braces
    - Expansion tanks
    - Fan guards

- Radiator Cap
  - Replace if seal is damaged, cracked, worn out or hardened
  - The spring, plunger and valves inside should have some resistance but still be easy to move

- Hoses & Lines
  - Inspect all hoses, lines or tubes for wear, cracks, corrosion or other damage and replace if necessary

- Inspect for hoses rubbing against metal parts or against each other
- Inspect for kinks, tight bends or twisted hoses or not enough slack
- Inspect for leaking or loose connections

- Fan
  - Inspect for cracks, chips or deformed blades and replace fan
  - Inspect for loose hub and bushing bolts or broken key or loose set screw
  - GHT does not support the replacement of individual fan blades as this could lead to excessive vibration and failure due to worn vs new blade deformation, instead it is recommended that the complete fan be replaced

- Cooler Grommets, Seals & Gaskets
  - These components will wear out over time when exposed to ultraviolet light, Ozone, heat cycling and dry conditions and will require periodic replacement
  - Inspect for cracked or dry rotted grommets, seals or gaskets and replace
  - Inspect for pinched grommets at tank to tube or tube to grommets as these could develop into leaks
  - In addition to regular cleaning, GHT recommends removal, flushing, and pressure testing any system at a certified GHT service facility on a yearly basis. Service intervals should not exceed two years. More frequent overhauls may be required depending on operating environment and conditions.
  - Replace worn, damaged or loose foam weather stripping located between the cooler and shroud/duct to limit air leaks and cooling performance degradation

- Coolers or Cores
  - Require regular cleaning to keep the external fins free of debris and the internal passages free of corrosion or scale buildup
  - Fins should be inspected for bent or dented fins and whenever possible should be gently straightened to maintain cooling performance
  - For excessive fin damage, missing or separated fins it is recommended that the cooler be serviced which may include repair or replacement
  - Removeable tube radiators may experience fin separation from the tube as they age and should be replaced with new tubes
  - Gasketed or grommeted coolers will require periodic maintenance to replace the grommet/seals
  - Verify that CAC coolers if mounted in a “free floating” frame are free to move without restriction between the stops to allow for thermal expansion