



HexFlow® RTM6/RTM6-2

Safety & Processing Recommendations
for Injection & Infusion

These recommendations along with the applicable Safety Data Sheet and Technical Data Sheet should be followed by all potential users of **RTM6 and RTM6-2** resins.

All users should make their own assessment of the application of these recommendations and products to their equipment, processes and end-use. Full-scale trials using the applicable equipment should be undertaken before commercial production.

HexFlow® and HiFlow® epoxy resin systems are suitable for liquid composite molding (LCM) because of their low viscosity when heated to the process temperature. It is this low viscosity that allows the reinforcement to be impregnated. Heating the resin also introduces risks associated with the thermal stability of reactive resins which could lead to an uncontrolled exotherm if not properly managed. However, the resin can be processed safely by strictly following this document's safety and processing guidelines.

A number of different LCM process technologies can be used for the manufacture of composite parts and this guidance is provided for the most commonly used process technologies. Each process has its own inherent safety risks leading to some differences in recommendations depending on the process technology considered.



HexFlow[®] RTM6/RTM6-2

Safety and Processing Recommendations

RTM6 and RTM6-2 have formulated epoxy resins that have the potential to exotherm when heated for an extended period of time. Processing of RTM6 and RTM6-2 can be conducted safely by controlling the temperature and heating time and incorporating the following guidelines into the customer's risk assessment of the injection or infusion process.

RTM6 and RTM6-2 - General Recommendations for Safe Handling and Contingency for Emergency Planning

Procedures:

- A formal written risk assessment must be completed specifically for any equipment using bulk RTM6 and RTM6-2 where heating is applied. To ensure a thorough assessment, cleaning procedures should also be risk assessed.
- Comprehensive process documents must be in place, including emergency plans and operator instructions.
- Operators must be fully trained to use the equipment and be aware of the emergency procedures associated with them.
- The equipment should be manned during the entire operation by trained operators, including loading the resin, infiltration, checking resin outlet traps, decanting excess resin and cleaning.
- Regular preventive maintenance must be conducted to ensure temperature controls, alarms, etc. are working correctly.

Emergency Procedures:

To manage stirrer failure or temperature rise, a contingency plan must be in place to provide instructions for the safe removal of hot resin from the mixing vessel or any equipment. Typically, the emergency procedure will include the following elements:

- An alarm that alerts the operator that the mixing element or stirrer has stopped or the temperature has risen above the maximum set point.
- In the case of over-heating or stirrer failure, procedures should be established whereby the hot resin can be quickly removed from the equipment and transferred to shallow metallic trays to enable rapid cooling. To expedite cooling, the metallic trays can be placed on a mobile unit, such as a pallet and transferred outside to air cool the resin.
- During emergency decanting, there is a risk of splash-back from hot, low viscosity resin. Direct contact with the resin can be avoided through the use of suitable personal protective equipment (PPE), such as a full-face visor with a cover to protect the neck and long gauntlet gloves. This should be included in the site PPE assessment and associated program.
- Personal protective equipment and emergency equipment must be available and easily accessible in the work area, in readiness for use in an emergency situation.

Operator Exposure to Chemicals:

- RTM6 and RTM6-2 contain epoxy resins, which can cause skin sensitization by either direct skin contact with the resin or contact with fumes generated by hot material.

Personal Protective Equipment:

- A task-specific PPE risk assessment should be completed to determine appropriate necessary protective clothing and materials. Generally, long-sleeve overalls, natural rubber or nitrile gloves, and safety goggles or a face visor are recommended when handling resin or conducting cleaning procedures on equipment used to handle RTM6 or RTM6-2.

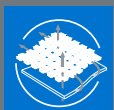
Engineering Controls:

- When the resin is heated above ambient temperature during processing and cleaning procedures, local exhaust ventilation should be used to avoid operator exposure to processing vapors. Please consult with a ventilation engineer to determine appropriate source control to minimize or eliminate potential exposure to vapors or gases.
- For degassing operations, vacuum pumps should be vented away from both the work area (usually outside) and workers. The operations should also be compliant with environmental permitting requirements and local operating conditions.
- Protective measures need to be in place to avoid operator exposure to processing vapors and gases generated during the curing process.

Equipment and Process Design:

Several different process technologies can be used in the manufacture of LCM parts. These guidelines provide generic recommendations for the following process technologies or steps:

- Heating resin cans of 10 or 25kg in an oven to reduce viscosity, prior to transferring to Resin Transfer Molding (RTM) and Liquid Resin Infusion (LRI) equipment.
- Conventional RTM process where the resin is held in a pressure pot capable of injection pressures up to 7 bar, with a maximum pot size of 50kg.
- Conventional RTM resin process, as above, where volumes of resin greater than 50kg are used presents additional risks.
- Piston injection equipment where resin is held in a cylinder capacity of up to 25kg and injection pressures up to 30 bar.
- Two-component resin mixing equipment where resin is mixed in a mixing vessel of up to 50kg capacity.
- Two-component resin mixing equipment where resin is mixed in-line either by static mixer (low pressure) or by an impingement mixing process (high pressure), generally referred to as high pressure RTM (HP-RTM).
- In all cases, an alarm needs to be an integral part of the temperature measurement and control to prevent an unsafe temperature from being reached.
- Mixing vessels and injection pots must be stirred continuously to ensure good temperature distribution and complete avoidance of hot spots.
- Resin cans and piston-type equipment will not generally be stirred; the additional risk associated with this needs to be considered in the risk assessment and process recommendations.
- Pressure relief venting sized for two-phase discharge should be incorporated into the process design. This should also be in accordance with globally recognized methods such as the Design Institute for Emergency Relief Systems (DIERS), which specifies sizing methods based on the worse-case, runaway scenarios identified via suitable process hazard analysis.



HexFlow® RTM6

Safety and Processing Recommendations

RTM6

Typical processing steps:

Step 1 – Preconditioning and Preheating

RTM6 previously stored at -18°C will require preconditioning at room temperature for 24 hours prior to the preheating step described below.

RTM6 10 or 25kg cans require preheating in an oven to reduce the viscosity and enable transfer to the resin process equipment. Critical control parameters to be considered are oven temperature and duration in the oven. An oven temperature of 50-70°C is considered adequate to sufficiently reduce the viscosity for transfer. The duration in the oven will depend on the oven design, but should never exceed 12 hours.

Step 2 – Transferring and holding in-process equipment prior to infiltration

Hexcel strongly recommends limiting the resin injection pot size to a maximum of 50kg. Larger vessels have an increased risk of exotherm and greater severity if an exotherm occurs. In cases where more than 50kg of resin is used, multiple 50kg resin pots in parallel should be used. Alternatively, a system where a 50kg resin pot is refilled by pumping extra resin from separate drums of RTM6 can be used. This reduces the exotherm risk associated with holding large quantities of resin at elevated temperatures for long periods of time. The resin pot design should incorporate a stirring device to ensure unified heat transfer to prevent hot spots from forming.

In the case where multiple pots are not practical and more than 50kg of resin are held in a single pot, additional risks arise which must be evaluated and incorporated into the process. If the plan is to deviate from the guidelines provided in this document, it is highly recommended to work with a safety consultant prior to using RTM6. By doing so, the proposed processing parameters can be evaluated and recommendations for safe operating and processing conditions can be made.

If quantities greater than 50kg are required of RTM6, it is strongly recommended to consider using RTM6-2 with an in-line mixing process. The quantity of mixed resin will be minimized and the risk and severity of exotherm significantly reduced.

For additional support, Hexcel Technical Support may be contacted. Visit hexcel.com/Contact/ for more information.

Different process technologies and material quantities give rise to different heat transfer conditions which dictate different recommendations for holding times and safe working times.

The recommended holding temperatures for the resin are in Table 1. These temperatures will provide low viscosity for processing and a safe working time of up to 12 hours. The safe working time should not be exceeded. In the case of RTM resin pots, if stirrer failure occurs, the maximum working time is significantly reduced and emergency action must be taken.

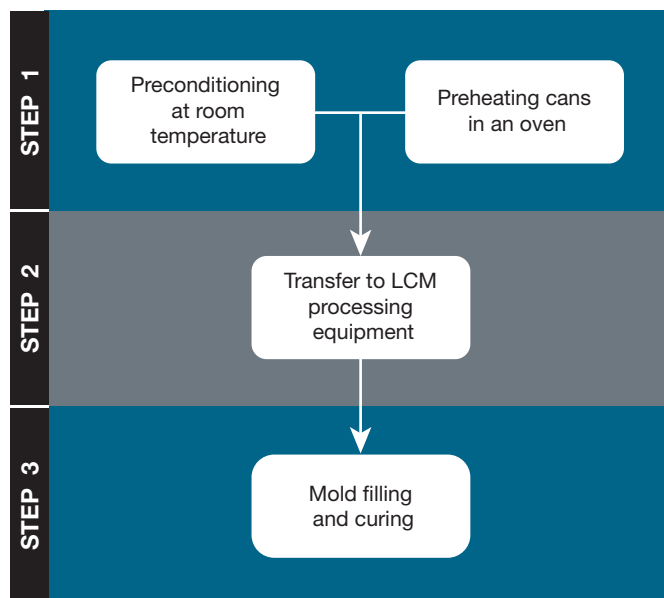


Figure 1 – Typical RTM6 Resin Processing Steps

Process	Recommended Heating Temperature (°C) for a maximum of 12 hours
10 or 25kg can in oven	50 - 70
Piston injector (<25kg) up to 30 bar pressure	60 - 70
Conventional RTM resin pot (<50kg), with stirring, up to 7 bar pressure	70 - 80
Conventional RTM resin pot (>50kg), with stirring, up to 7 bar pressure	≤ 60

Table 1 – Recommended Heating Times for Different Processes

The safe working time of 12 hours and recommended heating temperatures have been developed based on thermal stability data and kinetic modeling together with heat transfer models. This data is available on request to support customer's own risk assessments. It should be noted that the safe working time includes all processing steps where RTM6 is heated, including preheating prior to transfer to the process equipment and holding time in the process equipment. This guidance is based on the use of RTM6 that has not been previously heated and is within its guaranteed shelf life. This is because the resin has a thermal memory, repeated cooling and heating will reduce the time to exotherm, compromising the safe working time. **Therefore, if previously heated resin is used, prior heating temperatures and durations must be taken into account, so the total heating operations do not exceed the safe working time of 12 hours.**

Step 3 – Mold filling and curing

During mold filling and curing, the risk of runaway reaction is reduced but not eliminated. Resin is typically spread across a large tool area with good thermal conductivity and heat losses to the tooling. For thicker cross-sections and insulating reinforcements such as glass fibers, however, there is still a risk of uncontrolled reaction. Careful attention must be made to match resin cure cycles to the geometry of the part to be manufactured. Resin rich areas, such as inlet and feeding canals, must be carefully evaluated and dimensioned. Further advice on cure cycles should be sought from Hexcel Technical Support.

For isothermal processing where the mold is held at the curing temperature during resin injection, an assessment should be made based on part design to determine if there is a risk of thermal runaway in the tool or resin trap. Hexcel Technical Support should be contacted for further advice.



HexFlow[®] RTM6-2

Safety and Processing Recommendations

RTM6-2

Typical processing steps:

Step 1 - Preconditioning and Preheating

RTM6-2 may be supplied in cans, Part A (27kg) and Part B (19kg) or 210l drums, Part A (223kg) and Part B (155kg). Components previously stored at +5°C or below will require preconditioning at room temperature for 48 hours prior to the preheating step described below.

RTM6-2 Parts A and B require preheating in an oven to enable transfer to holding tanks or a mixing vessel for the mixing and degassing process step. For part A; an oven temperature of $\leq 90^{\circ}\text{C}$ for up to 24 hours is considered adequate to sufficiently reduce the viscosity for transfer. Part B is a solid that requires heating to $90\text{--}110^{\circ}\text{C}$ for up to 24 hours to melt to a low viscosity liquid for transfer.

Step 2 - Mixing and Degassing

Part A & B of RTM6-2 are required to be mixed and degassed.

When using tanks to hold Part A and Part B separately, followed by degassing, holding tank temperatures of $\leq 90^{\circ}\text{C}$ for Part A and Part B for up to 24 hours should be strictly followed.

When batch mixing in a vessel, followed by degassing, a mixing time of 20 minutes at a maximum temperature of 80°C should provide a homogeneous mix. Hexcel strongly recommends limiting the mixing volume to 50kg.

For quantities greater than 50kg, an in-line mixing system is recommended to avoid the need for holding mixed resin in bulk. This may be a system comprising of gear pumps and a static mixer or HP-RTM equipment utilizing high-pressure impingement mixing.

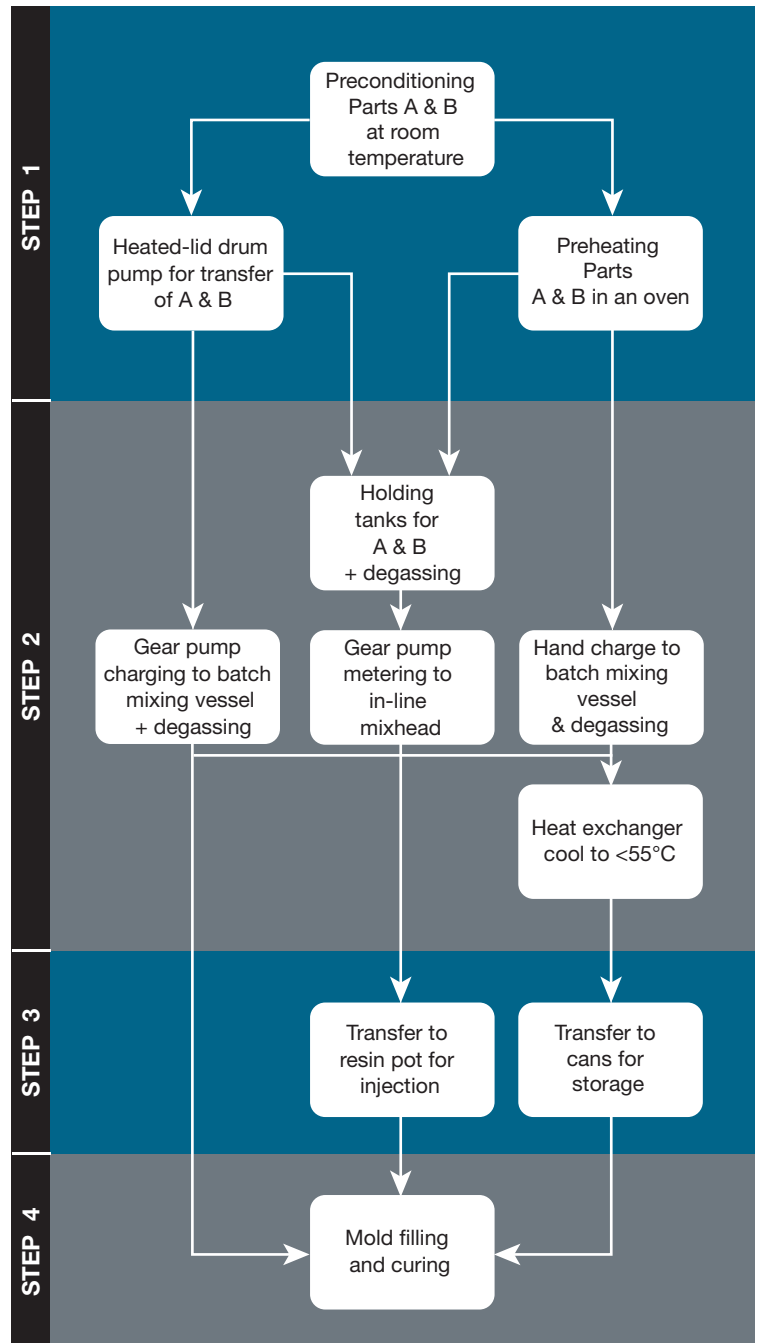


Figure 2 – Typical RTM6-2 Resin Processing Steps

Step 3 - Transferring and holding RTM6-2 in resin pot prior to infiltration

Hexcel strongly recommends limiting the resin injection pot size to a maximum of 50kg. Larger vessels have an increased risk of exotherm and greater severity if an exotherm occurs. In cases where more than 50kg of resin is required, a system where a 50kg resin pot is refilled by in-line mixing equipment is recommended. This reduces the exotherm risk associated with holding large quantities of resin at elevated temperatures for long periods of time. The resin pot design should incorporate a stirring device to ensure unified heat transfer to prevent hot spots from forming.

If the plan is to deviate from the guidelines provided in this document, it is highly recommended to work with a safety consultant prior to using RTM6-2. By doing so, the proposed processing parameters can be evaluated and recommendations for safe operating and processing conditions can be made.

For additional support, Hexcel Technical Support may be contacted. Visit hexcel.com/Contact/ for more information.

The recommended holding temperatures for the mixed resin are in Table 2. These temperatures will provide low viscosity for processing and a safe working time of up to 12 hours. The safe working time should not be exceeded.

Process	Recommended Heating Temperature (°C) for a maximum of 12 hours
10 or 25kg can in oven	50 - 70
Piston injector (<25kg) up to 30 bar pressure	60 - 70
Conventional RTM resin pot (<50kg), with stirring, up to 7 bar pressure	70 - 80

Table 2 – Recommended Heating Times for Different Processes

The safe working time of 12 hours and recommended heating temperatures have been developed based on thermal stability data and kinetic modeling together with heat transfer models. This data is available on request to support customer's own risk assessments. It should be noted that the safe working time includes all processing steps where RTM6-2 is heated, including preheating prior to transfer to the process equipment and holding time in the process equipment. This guidance is based on the use of RTM6-2 which has not been previously heated and is within its guaranteed shelf life. This is because the resin has a thermal memory, repeated cooling and heating will reduce the time to exotherm, compromising the safe working time. **Therefore, if previously heated resin is used, prior heating temperatures and durations must be taken into account, so the total heating operations do not exceed the safe working time of 12 hours.**

In the case of direct injection into the tool, resin is not held in bulk and a process temperature of 80°C may be used for the resin mixing stage by a static mixer or impingement mix-head (HP-RTM).

Step 4 – Mold filling and curing

During mold filling and curing, the risk of runaway reaction is reduced but not eliminated. Resin is typically spread across a large tool area with good thermal conductivity and heat losses to the tooling. For thicker cross-sections and insulating reinforcements such as glass fibers, however, there is still a risk of runaway reaction. Careful attention must be made to match resin cure cycles to the geometry of the part to be manufactured. Resin rich areas, such as inlet and feeding canals, must be carefully evaluated and dimensioned. Further advice on cure cycles should be sought from Hexcel Technical Support.

For isothermal processing where the mold is held at the curing temperature during resin injection, an assessment should be made based on part design to determine if there is a risk of thermal runaway in the tool or resin trap. Hexcel Technical Support should be contacted for further advice.

Supporting documentation

Users are also strongly advised to follow the Safety Data Sheet and Technical Data Sheet for these products. Documents are available from the Hexcel website and Hexcel Technical Support who are happy to discuss any questions or concerns.

All information has been prepared with reasonable skill and care but is given without acceptance of liability. All users should make their own assessment of the suitability of the products for their equipment and process, and the purpose required.

Hexcel Product Family



For more information

Hexcel is a leading worldwide supplier of composite materials to aerospace and industrial markets. Our comprehensive range includes:

- HexTow[®] carbon fibers
- HexFlow[®] RTM resins
- Engineered core
- HexForce[®] reinforcements
- HexBond[®] adhesives
- Engineered products
- HiMax[®] multiaxial reinforcements
- HexTool[®] tooling materials
- Polyspeed[®] laminates & pultruded profiles
- HexPly[®] prepregs
- HexWeb[®] honeycomb
- HexAM[®] additive manufacturing
- HexMC[®]-i molding compounds
- Acousti-Cap[®] sound attenuating honeycomb

For U.S. quotes, orders and product information call toll-free 1-866-601-5430. For other worldwide sales office telephone numbers and a full address list, please go to:

<https://www.hexcel.com/contact>

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