



# Q1/Q3 Cryo-Assembly Cool-down/Warm-up Estimates

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# Cool-down/Warm-up Method

- Controlled cool-down with He supply temperature 50 K below maximum measured cold mass temperature.
- Controlled warm-up with He supply temperature 50 K above minimum measured cold mass temperature.
- Method:
  - Mix 300 K GHe and 80 K GHe outside the test stand feed box to achieve the required supply temperature.
  - If GHe supply temperatures below 80 K are required, we will need to implement a second mode where 80 K GHe and 4.5 K LHe are mixed inside the test stand feed box.
  - **Question: Over what cold mass temperature ranges are controlled cool-down/controlled warm-up required? (There is little additional thermal contraction between 80 K and 4.5 K)**
  - **Comments: No additional upgrade is required for mixing LHe and 80 K GHe, only need to make it a steady cooldown. Similar procedure is already developed at VMTF.**

# Cool-down/Warm-up Estimates

- At 20 g/s He flow rate with 50 K  $\Delta T$ , calculated cool-down time from CFD analysis is 109 hr.
  - For comparison, 57 hr with 100 K  $\Delta T$ .
- Warm-up is estimated to take 1/3 longer
  - 145 hr with 50 K  $\Delta T$
  - 76 hr with 100 K  $\Delta T$ .
  - Comments: assume ~ 80h. of cooldown/week with 2-shift weekdays and 1-shift weekend.

