

High- and Low-Temperature Storage Testing

Preface

MAXMAC evaluates ion modules after unpowered exposure to cold and heat. The procedure combines defined chamber conditions, natural recovery to room temperature and checks of current, LIN communication, ion output and physical condition.

This note presents the complete storage sequence, chamber arrangement, temperature programs and recovery checks. The completed verification covers six samples exposed to -40°C for 24 hours and $+85^{\circ}\text{C}$ for 48 hours. All six samples met the reported requirements after both storage stages.

Purpose and Test Conditions

The test evaluates retained function and physical condition after storage exposure. Samples remain **unpowered during storage** (mode 1.1), then recover naturally to room temperature for the post-storage checks.

Complete Test Sequence

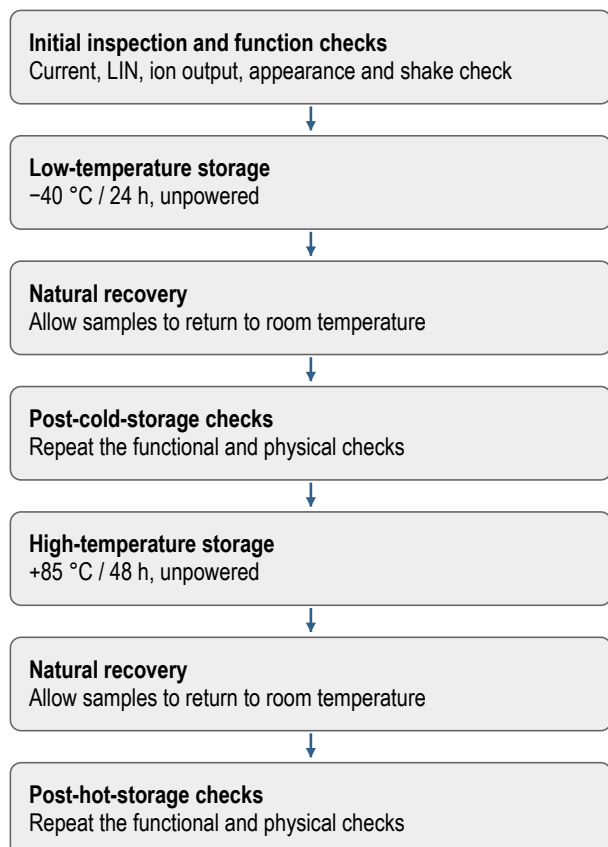
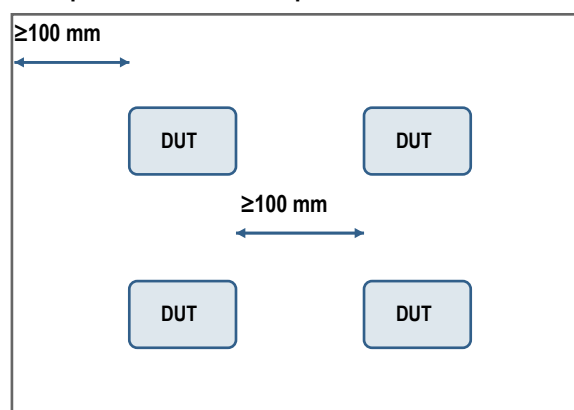


Figure 1 Storage and recovery sequence. After cold storage, ion-output measurement follows more than 2 hours of standing time and evaporation of condensation.

Chamber Arrangement

Temperature chamber - top view



Sample to wall

Sample to sample

Figure 2 Specified clearances: at least 100 mm between samples and at least 100 mm between samples and chamber walls.

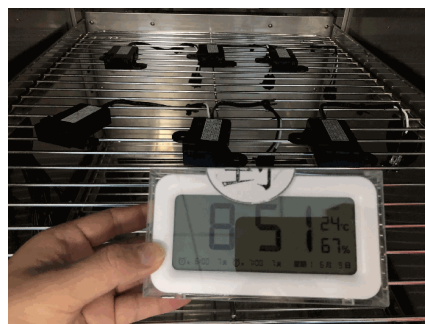


Figure 3 Original chamber setup showing the test samples on the chamber rack.

Equipment

Temperature chamber: **GFS-400-10** (E-033).

Ion tester: **NKMH-103**.

Anemometer: **PROVA AVM-07**.

Temperature Programs and Recovery

Low-Temperature Storage

Set the chamber to **-40 °C**. Once stable, maintain the unpowered storage condition for **24 hours**.

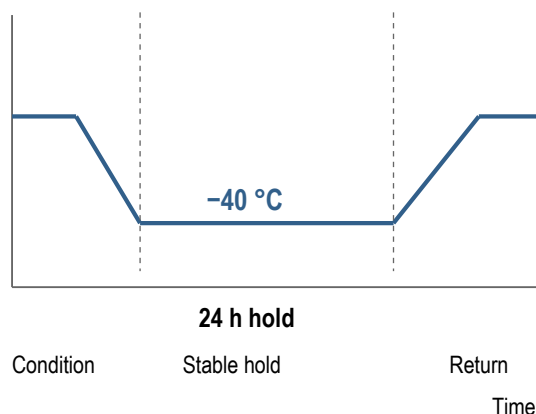
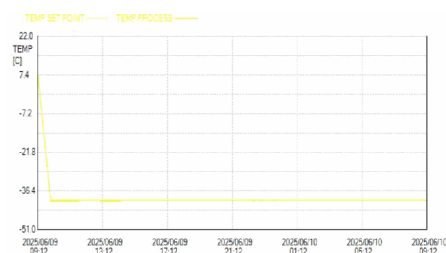
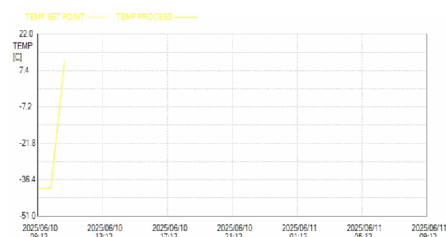


Figure 4 Cold-storage program schematic.

Program schematic; time axis is diagrammatic. The hold begins after chamber temperature stabilizes.



Original chamber record: cold-storage exposure.



Original chamber record: temperature return at the end of the cold stage.

Recovery and Recheck

Allow samples to recover naturally to room temperature, then perform the functional and physical checks. For ion-output measurement after cold storage, leave the samples standing for **more than 2 hours** and allow condensation to evaporate before measuring.

High-Temperature Storage

Set the chamber to **+85 °C**. Once stable, maintain the unpowered storage condition for **48 hours**.

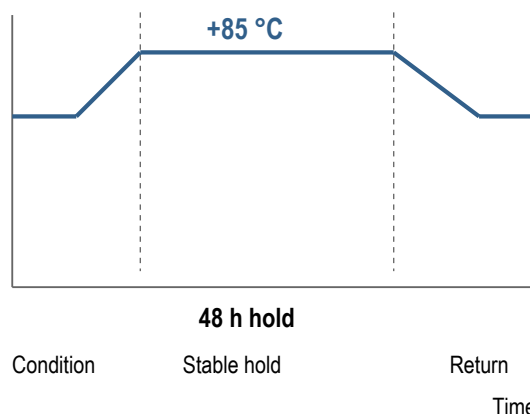
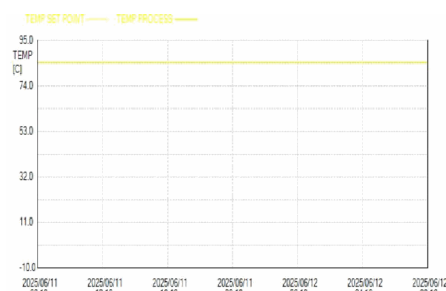
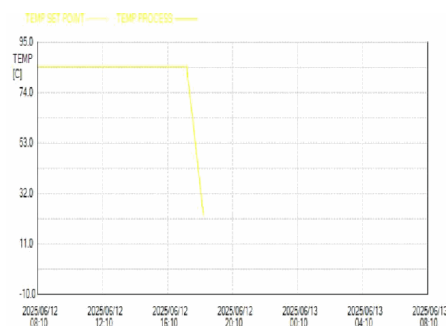


Figure 5 Hot-storage program schematic.

Program schematic; time axis is diagrammatic. The hold begins after chamber temperature stabilizes.



Original chamber record: hot-storage exposure.



Original chamber record: temperature return at the end of the hot stage.

Recovery and Recheck

Allow samples to recover naturally to room temperature, then perform the functional and physical checks. Record current, LIN status, ion output, appearance and the shake-check result against each sample identification.

Post-Storage Checks and Results

All six samples met the reported requirements after both storage stages. The acceptance checks link the measured and observed results to specific module functions.

Check	Acceptance requirement	What is checked after recovery
Supply current	$I \leq 0.1 \text{ A} = 100 \text{ mA}$	Current consumption meets the specified limit.
LIN communication	Normal communication; no message errors or faults	Communication function remains normal.
Ion output	Reported as $>20 \text{ million ions/cm}^3$	Ion generation meets the specified output threshold.
Appearance	No abnormal appearance or damage	No visible abnormality or damage is recorded.
Shake check	No abnormal internal noise	No abnormal sound is recorded during shaking.

Table 1 Functional and physical checks performed after recovery.

Recorded Current by Sample

Sample	Before cold storage Current (mA)	After $-40 \text{ }^{\circ}\text{C}$ / 24 h Current (mA)	After $+85 \text{ }^{\circ}\text{C}$ / 48 h Current (mA)	Result
01	14.1170	13.3730	13.9052	Pass
02	13.3912	13.4485	13.6897	Pass
03	14.1680	14.1457	14.4716	Pass
04	13.1999	12.9420	13.6333	Pass
05	14.0103	13.6072	13.8985	Pass
06	14.7419	14.2927	14.6282	Pass

Table 2 Original current readings. LIN, ion output, appearance and shake checks also passed for all six samples after both stages.

Ion-Output Record

For all six samples, the ion tester indicated -1 , identified in the report as **over range above 20 million ions/cm³**. The report records the ion-output check as passing before and after storage.

Verification Summary

After both storage stages, the recorded currents remained below 100 mA, LIN communication was normal, ion output met the requirement, appearance showed no abnormality and shaking produced no abnormal internal noise.

Test Basis and Records

Cold storage: **Q/MAT 5502-2023, 9.2.1.**

Hot storage: **Q/MAT 5502-2023, 9.3.1.**

The laboratory record retains sample identities, chamber settings, temperature records, setup photographs and post-storage inspection results.

Source: MAXMAC laboratory report, Leg1, pp. 5-17. Sample labels 01-06 correspond to 1#-6#. Unpowered storage mode confirmed by MAXMAC.

Revision 1.1: 19 October 2026. Added the complete sequence, chamber-clearance diagram, temperature programs, original curves and post-storage check explanations.