



t-Global Technology

GT15 Reliability Report

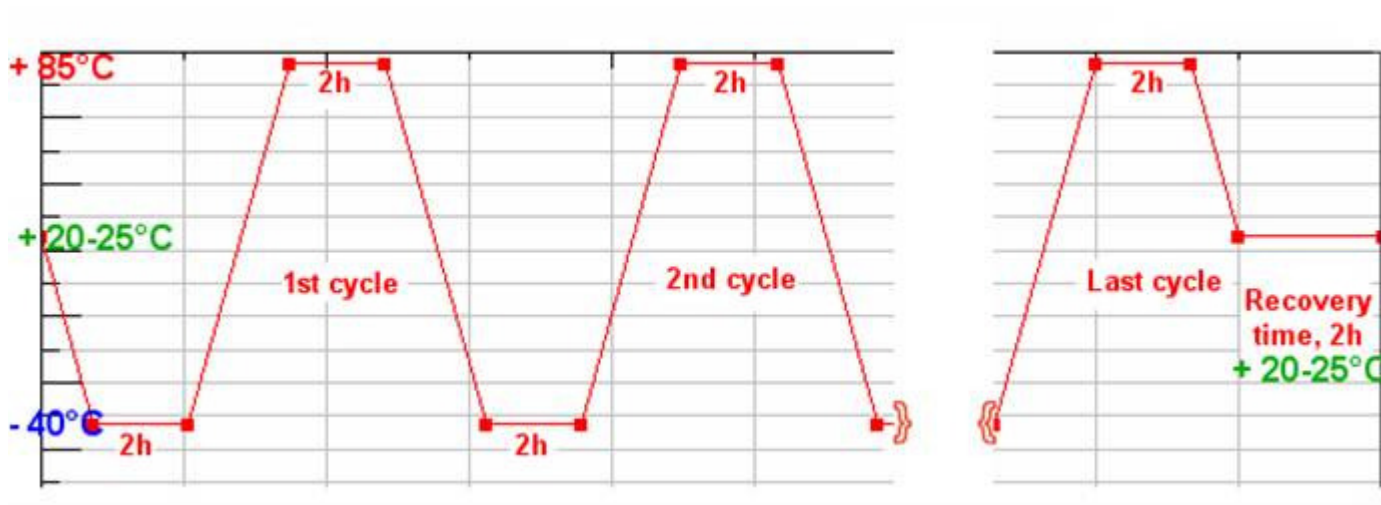
Overview

- This document relates to the testing and qualification of GT15 for IUSA, Mexico
- The following standards were referenced for this testing:
 - ASTM D5470
 - ASTM D257
 - ASTM D2240
 - MIL-STD-810F

Thermal Cycling

- This test is used for thermal ageing for materials used in components, modules, mechanisms etc. to ensure reliability of material or connections between parts (e.g. reliability of plastic parts connections)
- Recommended minimum sample size: 3x3 cm
- Minimum sample amount 10 pcs
- Temperature shock chamber or 2 separate temperature chambers
- Test equipment for thermal and mechanical performance verification after the test
- Before the test the samples are checked in the laboratory environment to ensure normal performance.
- The samples are placed to the temperature chamber, which is then decreased to - 40 °C
- After 2 hours dwell the samples are moved to the temperature chamber which is at + 85 °C. The changing time should be less than 3 minutes
- The samples are kept for 2 hours at + 85 °C
- After 2 hours the samples are moved to the chamber that is at - 40 °C
- Repeat cycle specified in steps 3-5 four additional times
- After 5 cycles the samples are set to room temperature for recovery
- After 2 hours recovery times the final measurements are carried out in the laboratory environment to ensure normal performance

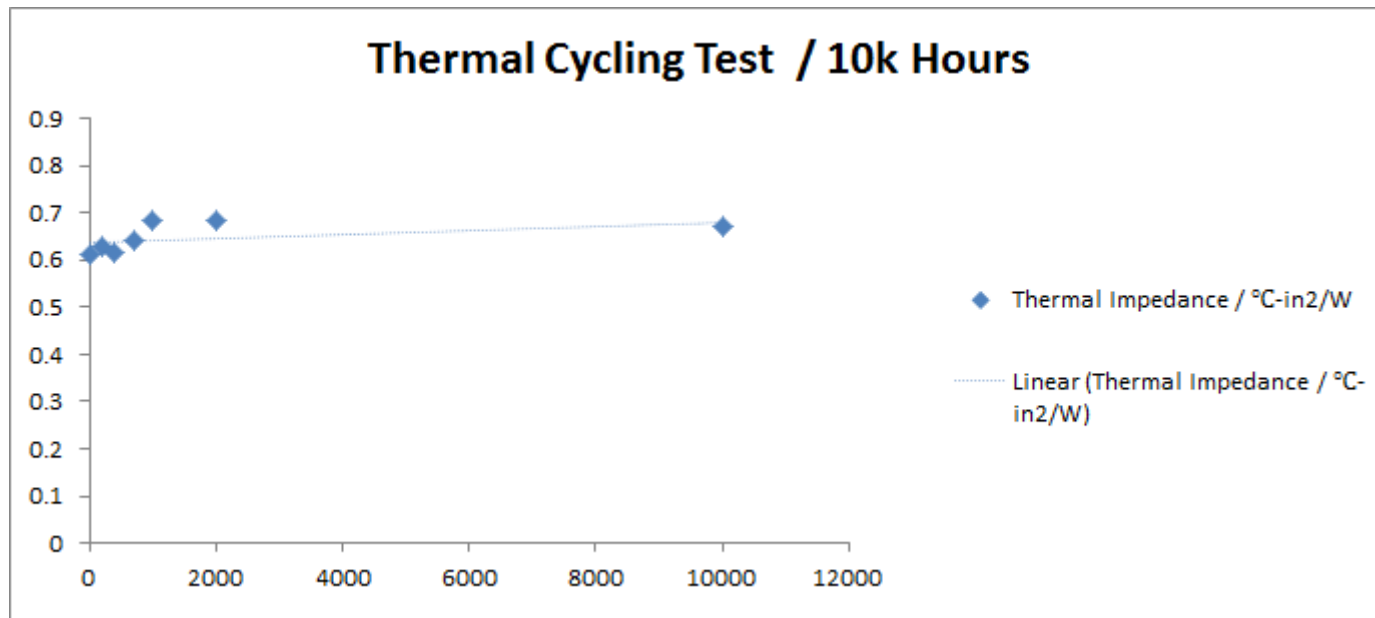
Thermal Cycling



Thermal Cycling

- Acceptance Criteria:
 - Mechanical decomposition is allowed as long as the material still remains within specification after testing.
 - Thermal decomposition is allowed as long as the material still remains within specification after testing.
 - Unless specified by project: Mechanical and thermal properties must be within $\pm 10\%$ of original values after the thermal cycling test.

Thermal Cycling Test - Results



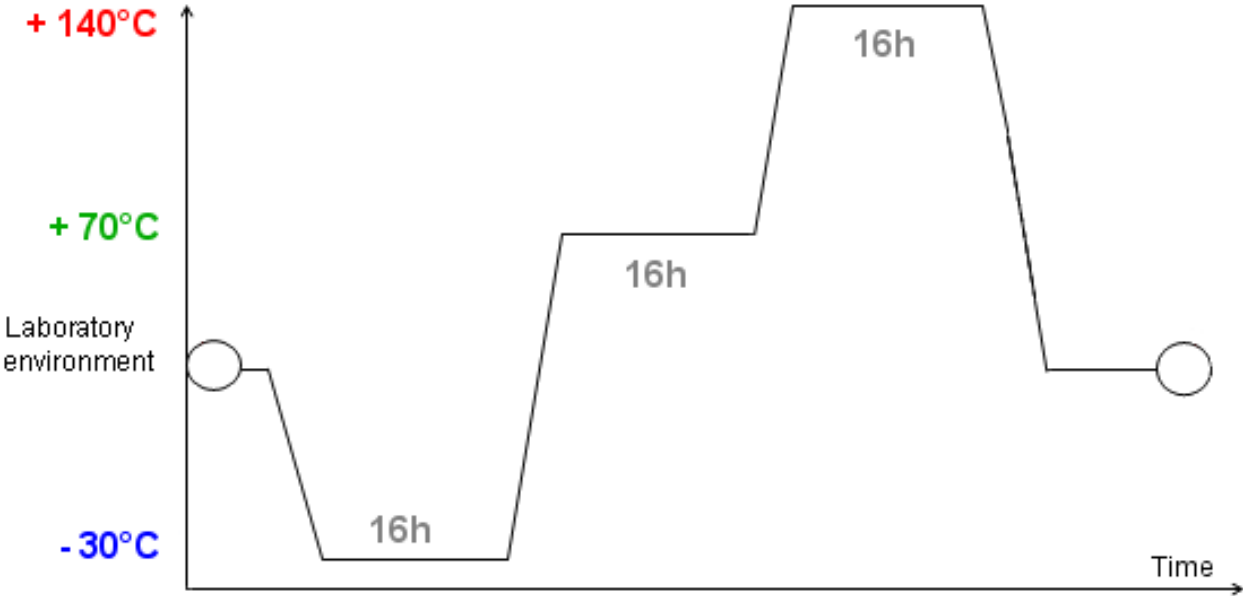
Steady Temperature Test

- The purpose of the test is to ensure the suitability of the TIM sample while using whole product in cold or in hot air conditions but also using sample against hot component.
- Samples shall be verified using operational temperatures -30°C and $+70^{\circ}\text{C}$.
- A maximum surface temperature in hot spots of components is expected to be no more than $+140^{\circ}\text{C}$ and therefore for step three $+140^{\circ}\text{C}$ is taken in use.
- Recommended minimum sample size: 3x3 cm
- Minimum sample amount 10 pcs
- Equipment needed:
 - Temperature chamber
 - Test equipment for thermal and mechanical performance verification after the test

Steady Temperature Test

- Install TIM on to the test plate
- The samples are placed into the test chamber
- The chamber temperature is decreased with a gradual change of 1 °C/min from room temperature to -30 °C for 16 hours.
- After 16h the functionality of TIM need is verified and suitable measurements will be carried out when needed.
- After inspection at -30°C the chamber temperature is increased with a gradual change of 1 °C / min from -30°C to +70 °C for 16 hours.
- After inspection at +70°C the chamber temperature is increased with a gradual change of 1 °C / min from +70 °C to +140°C for 16 hours
- After 16h temperature is decreased with gradual change of 1 °C / min from +140 °C to room temperature
- After 2 hour recovery in the room temperature the final measurements are carried out in the laboratory environment to ensure normal performance of sample.

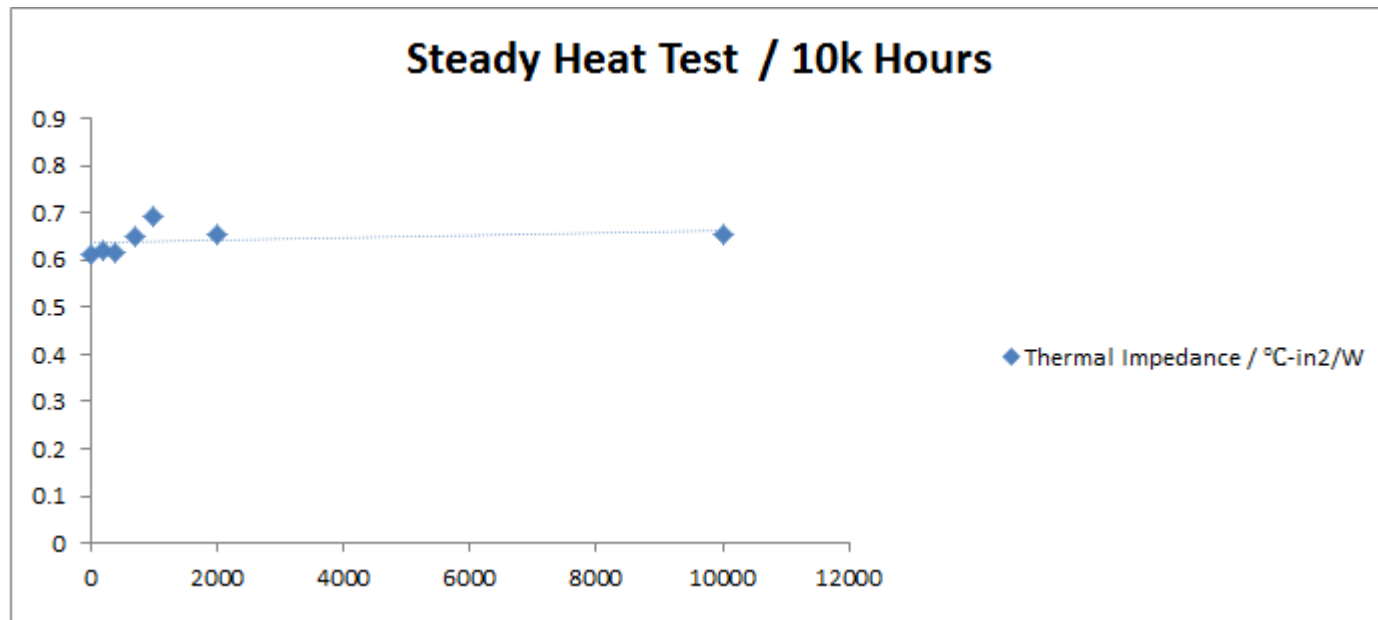
Steady Temperature Test



Steady Temperature Test

- Acceptance Criteria:
 - Mechanical decomposition is allowed as long as the material still remains within specification after testing.
 - Thermal decomposition is allowed as long as the material still remains within specification after testing.
 - Unless specified by project: Mechanical and thermal properties must be within $\pm 10\%$ of original values after “Steady temperature”- test.

Steady Temperature Test - Results



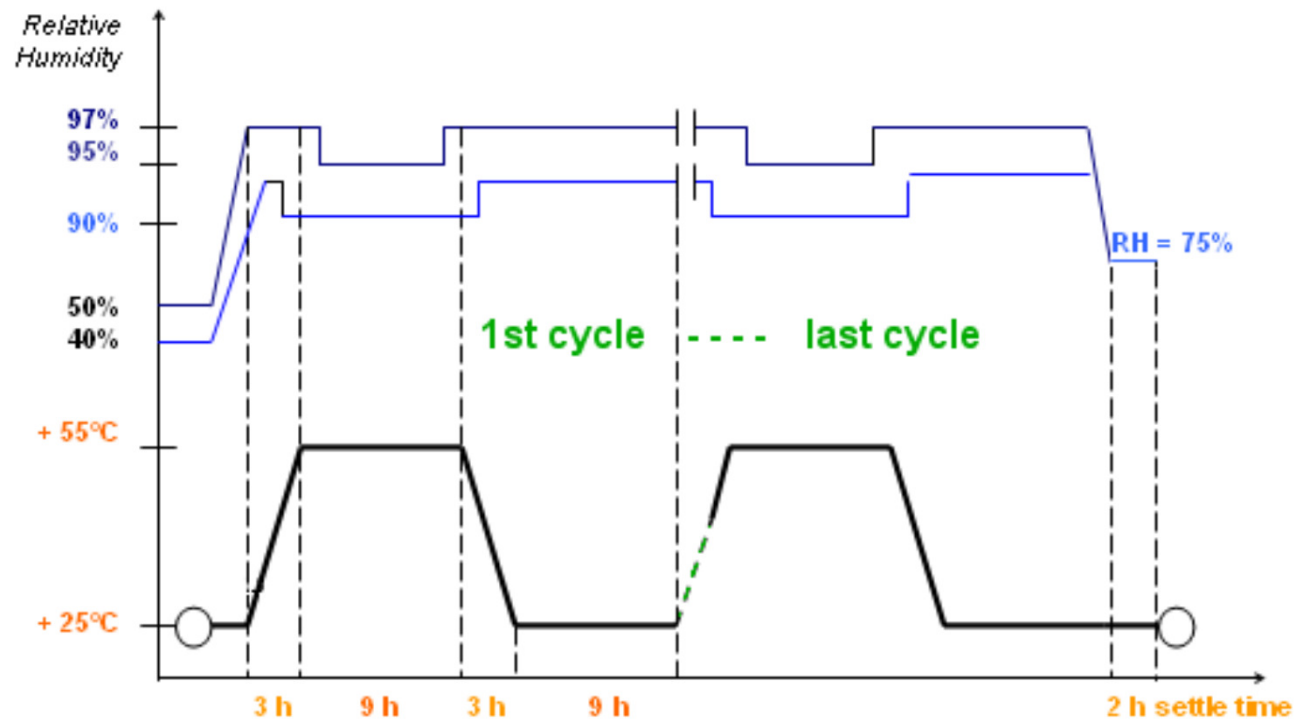
Damp Heat Thermal Cycling

- The purpose of the test is to determine the suitability of the sample for use and storage under conditions of high humidity combined with cyclic temperature changes.
 - Recommended minimum sample size: 3x3 cm
 - Minimum sample amount 10 pcs
 - Equipment needed:
 - Climatic chamber
 - Test equipment for thermal and mechanical performance verification after the test

Damp Heat Thermal Cycling

- Before the test samples are checked to ensure normal performance.
- The samples are placed (power ON in case of functional samples) to the test chamber, which is at +25 °C with relative humidity 95 %.
- Then the temperature is continuously increased in 3 hours to + 55 °C. During this period the relative humidity shall be between 93...96 %.
- The temperature is maintained at +55 °C for 9 hours.
- Then the temperature is decreased to +25 °C in 3 hours with relative humidity between 95...100 %.
- The temperature is maintained at +25 °C for 9 hours to complete the 24 hours cycle.
- This 24 hours cycle is repeated 17 times more.
- After 18 cycles (18 days) the chamber temperature is set to +25 °C and relative humidity to 75 % for two hours.
- After this settle time the samples must be checked **as soon as possible** functionally to ensure normal thermal, electrical (when valid) and mechanical performance. The total testing time will be then **18 days**.

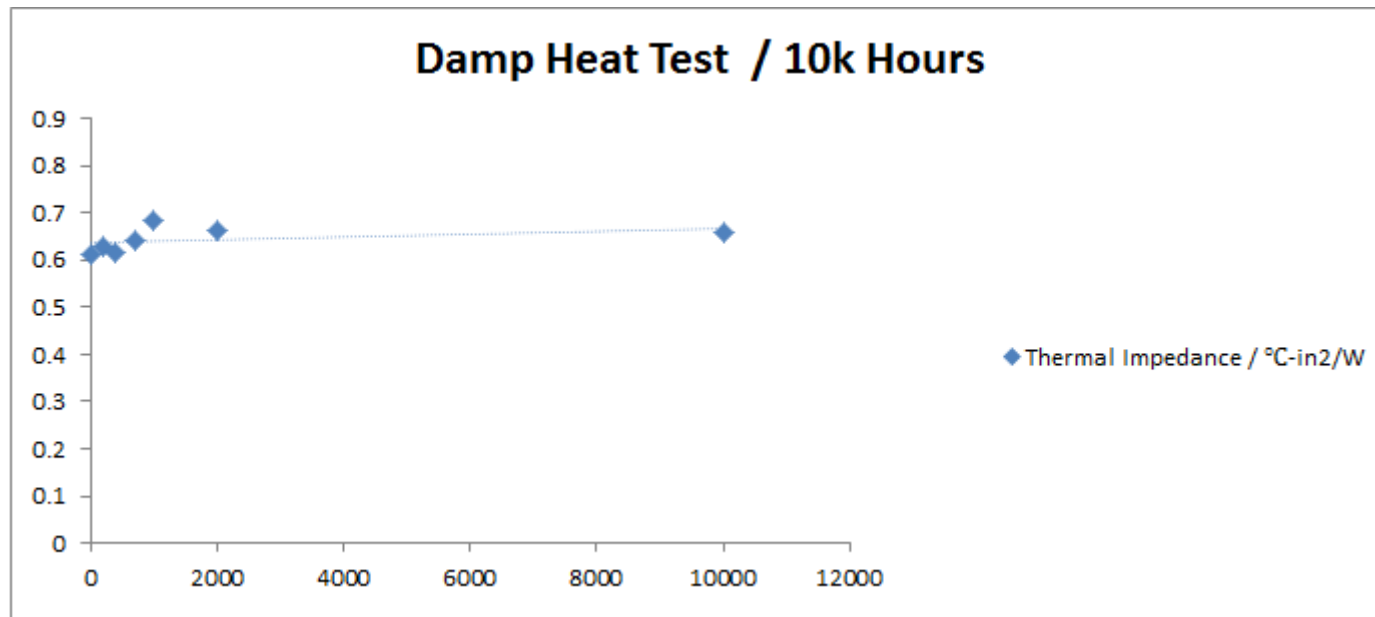
Damp Heat Thermal Cycling



Damp Heat Thermal Cycling

- Acceptance criteria:
 - Mechanical decomposition is allowed as long as the material still remains within specification after testing.
 - Thermal decomposition is allowed as long as the material still remains within specification after testing.
 - Unless specified by project: Mechanical and thermal properties must be within $\pm 10\%$ of original values after “Damp Heat Cyclic”- test.

Damp Heat Test - Results



Adhesion Strength Measurements

- Purpose is to measure the strength of adhesive.
- Adhesives shall be exposure under several stresses and adhesion forces shall be measured before and after the following tests:
 - Steady Temperature Test,
 - Change of Temperature
 - Damp Heat Cyclic.
- The requirements for this test are:
 - Pull-out speed 1000 mm/min (note that sampling rate shall be fast enough)
 - Pull-out length min 25 mm
 - Pull-out angle: 180°
 - Material tensile tester, e.g. Lloyd LRX Plus
 - Minimum sample amount 5 pcs

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Adhesive Strength Measurements

- Test procedure
 - Glue sample to specified sample area
 - Wait 5 minutes
 - After 5 minutes fasten adhesive to pull-out test jig and measure adhesion by pulling sample out.

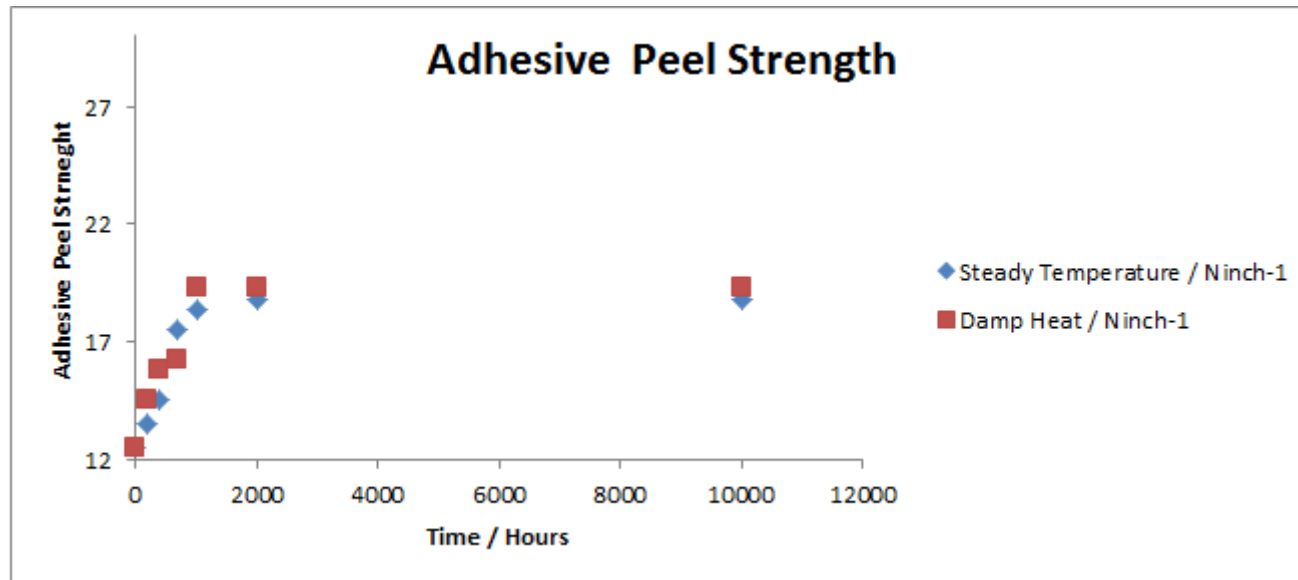
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Adhesive Strength Measurement

- Acceptance criteria:
 - Adhesive forces according product specification
 - Unless specified by project: After environmental test adhesion properties shall be within $\pm 25\%$ of original forces.

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Adhesive Peel Strength Test - Results



Summary

- Under all the test criteria GT15 exhibited stability over 10k hours
- At the end of each test the product remained in specification as per the data sheet and was deemed fit for purpose
- GT15 passes all the requirements as outlined under MIL-STD-810F