Title		Reg.
Clipper 5 ed 2: Shelf Life Test		
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Summary

The purpose of the test has been to verify the function of the Clipper 5 ed 3, after 10 years, during which time it has alternatively been stored in a normal room environment and brought at rescue actions at varying climate conditions.

The critical part is the propellant container with the propellant charge.

The accelerated ageing (temperature and time) was designed according to the known activation energy for chemical decomposition of the propellant. The test schedule included changes between 50 % RH and 95 % RH to simulate transport between storage and working conditions. A period with marine environment was also included.

The test objects were quite severely corroded after the ageing period. As can be seen by the description of the ageing conditions, the objects have been exposed to a very corrosive environment, probably worse than the conditions during their future lifetime.

The function was tested at normal working conditions. 9 of 10 objects were tested and all 9 cut the wire with no misfunction.

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Contents:

1 INTRODUCTION AND PURPOSE

The purpose of the test has been to verify the function of the Clipper 5 ed 2, after 10 years, during which time it has alternatively been stored in a normal room environment and brought at rescue actions at varying climate conditions. The probable number of rescue actions during the lifetime of the product has not been defined, and thus it was necessary to estimate a reasonable test schedule.

2 CRITICAL COMPONENTS

When the materials and components involved in the product were surveyed, it was considered that the critical part is the propellant container with the propellant charge. The container is sealed with a sealing lacquer. However, during the storage and the periods of rescue actions, slow moisture diffusion will take place. It is necessary to seal perfectly in order to avoid leakage, which would increase the risk of misfunction.

The tool is made of the same materials as the original Clipper (for use on fishing boats) and has already been tested properly without any problems.

3 TEST DESIGN

3.1 General discussion

According to Milstandard 810 a test procedure is recommended with change of temperature between 25 – 60°C and a change of relative humidity (RH): 50 – 95 %. This is described as a test schedule for environmental durability test.

It is quite possible to design a test schedule for the shelf life test including the test parameters mentioned above. The storage periods can be simulated by accelerated ageing at +60°C in an environment with about 50 % RH and the periods of use will be simulated by a number of interruptions in the accelerated ageing with the test specimens kept at +25°C and about 95 % RH. The change of temperature and RH will cause ”breathing” in the test objects, which will be of the same type as in real use. It is also desirable to include a test sequence that will simulate a marine environment.

3.2 Accelerated ageing

When the ageing of the product is considered, the critical material will be the propellant. Fortunately we already know the activation energy (E_a) of the decomposition of this propellant. $E_a \approx 100$ kJ/mole.

E_a is often calculated with a modified version of the Arrhenius' equation, i.e.

$$k = e^{-\frac{E_a}{RT}}$$

where: k = reactionrate
E_a = activation energy
R = Gas Constant = 8.3143 J/mole · K
T = temperature (K)

The Arrhenius' equation describes the temperature dependence of the reaction rate. If E_a is high, the rate increases more as the temperature increases, than if E_a is low. The E_a value has been obtained by investigations in a microcalorimeter, a very sensitive instrument that measures the heat flows of chemical reactions. (It can be used to test material stability, compatibility between substances, calculation of activation energies etc.)

3.3 Discussion of ageing method

The following method was planned in order to make the changes of temperature and RH possible with a reasonable working time.

About 50 % RH was obtained by using a saturated solution of $NaNO_2$. A saturated salt solution will always be in equilibrium with a certain RH at a certain temperature (different for different salts). This is a very stable method of keeping a certain RH even if the container is opened without cooling, which is necessary in this test. The test objects were placed in a desiccator containing a suitable amount of the saturated salt solution and the desiccator was kept at +60°C. Once a day (4 times every week) the desiccator was taken out and opened. The test objects were moved to another desiccator containing water, which gives about 95 % RH. After 4 hours in this environment at room temperature, the test objects were again placed in the desiccator with 50 % RH in +60°C.

We also found it recommendable to add a test period with simulation of contact with seawater. It is not possible to obtain such conditions during the period of ageing in 50 % RH, since adding of NaCl would cause a change in RH. Thus, after a period of change between 25°C/95 % RH and 60°C/50 % RH, the rest of the ageing at 60°C was performed at about 75 % RH, obtained with a saturated NaCl-solution. The test objects were also sprayed with a salt solution before this ageing period. The test period at +75 % RH was 3 weeks, and half of this ageing period was performed before the "change period" and half afterwards.

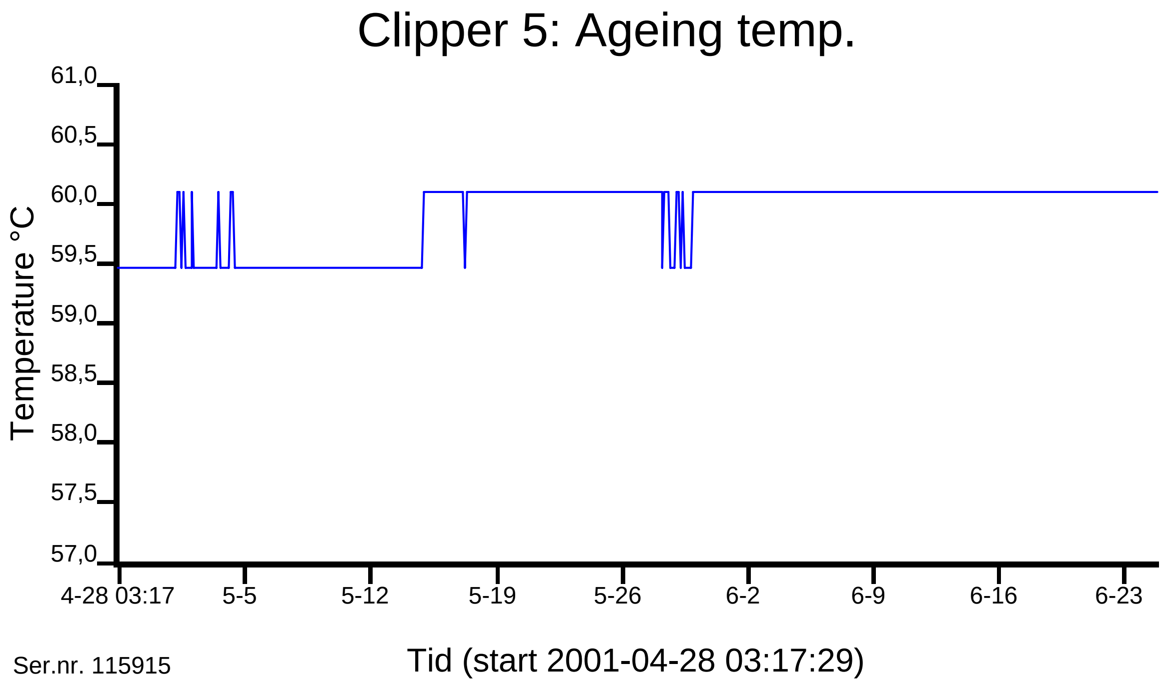
3.4 Schedule of all test parameters

Number of test objects	10	Propellant conditioned to normal RH
E_a = activation energy	100 kJ/mole	
Normal storage temperature:	+25°C	Estimated value
Temperature of accelerated ageing	+60°C	
Acceleration factor	69,55	Calculated from Arrhenius' equation
Simulated time	10 years	Stated in product requirements
Accelerated ageing time	52 days	RH ≈ 50 % obtained by a saturated solution of $NaNO_2$
Number of periods at +25°C and 95 % RH during accelerated ageing	20	Estimated to be a reasonable value
Time for each period at +25°C	4 hours	+0,5 h for increase of temperature: total time about 100 hours = 4 days
Total time with change 25° - 60°C	35 days	Estimated as a relevant part of the ageing time
Time at +60°C and 75 % RH (half the time before temperature change period and half afterwards)	3 weeks	75 % RH obtained by presence of saturated NaCl-solution, test objects sprayed with salt solution
Total ageing time including interruptions	8 weeks	56 days, in accordance with calculated ageing time (52 + 4)

3.5 Test performance

The accelerated ageing was carried out according to the method described in sections 3.3 and 3.4.

The temperature was continuously controlled by a temperature data logger. The result is shown below.



The interruption periods at room temperature have not been documented with this method, but the temperature was between +20°C and +25°C during the test period.

4 TEST AFTER ACCELERATED AGEING

4.1 Visual inspection

The test objects were quite severely corroded after the ageing period. As can be seen by the description of the ageing conditions, the objects have been exposed to a very corrosive environment, probably worse than the conditions during their future lifetime.

4.2 Function test

The function was tested with the normal test method. 9 of 10 objects were tested and all 9 cut the wire with no misfunction.