Stress Corrosion Cracking of Metals in Propellants

ILSE ALCANTARA **575-525-7634 ilse.alcantara@nasa.gov**

HAT: 2.1c **TA:** 2.1.1 – In-Space Chemical Propulsion Technologies, 12.1.4 – Materials for Extreme Environments
TRL: start 3 / current 4

OVERVIEW

Stress corrosion cracking (SCC) of a fracture critical metallic material can cause a premature failure if the material is susceptible in the unique service environment. Material fluid compatibility is an area of interest for the current NASA programs leading the human exploration path to Mars. White Sands Test Facility, the agency's lead on hypergolic propellant testing, identifies a lack in stress corrosion cracking susceptibility data for metallic materials in hypergolic propellants. The development of a stress corrosion cracking screening method is necessary to bridge the knowledge gap and enable the community to more confidently select materials for the use in systems containing corrosive fluids.

INNOVATION

Currently, NASA's approach to metallic material compatibility in propellants includes both an evaluation of chemical reactivity and material susceptibility to stress corrosion cracking in the given environment. The NASA-STD-6001.B contains Test 15 which is a well-defined method to test materials based on their chemical reactivity and compatibility with the fluid of interest.

Metals - Fluid Systems Ratings MAPTIS MATERIALS AND PROCESSES TECHNICAL INFORMATION SYSTEM

Rating criteria per NASA-STD-6001B:

Materials in Contact with Hydrazine Ratings
A = stress corrosion cracking does not occur in a time representative of the system service life at a stress level of 75% of tensile yield for aluminum alloys and 95% of tensile yield for all other alloys.
B = fluid decomposition is neither catalyzed nor accelerated by the metal at specific temperature of 160 F if not specified.
X = materials which fail ratings A and B above.
I = material with insufficient data.
U = material which was not tested.

Metals - Stress Corrosion

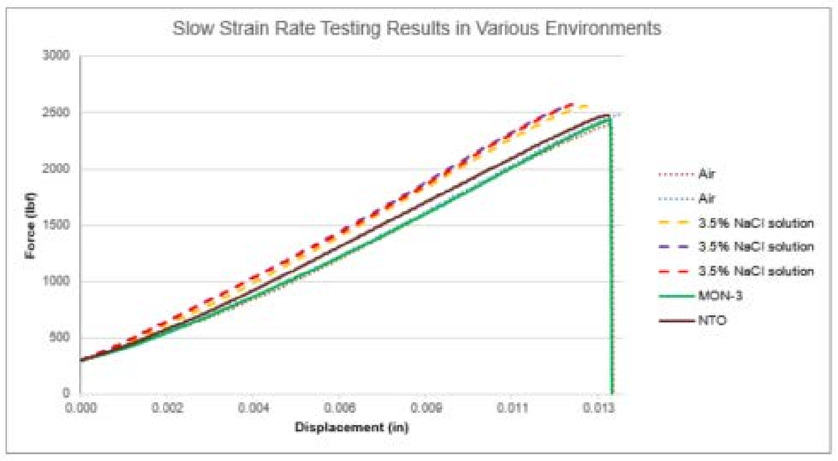
Mtrl. Code	10009	Test Rpt. No		Test No./Type	SCC/SCC
Rating	A	Reference	156	Press.(psia)	
Temp1 (F)		Temp2 (F)		SCC Resist.	HIGH
Thresh				Environment	SODIUM CHLORIDE (NACL)

As for the stress corrosion cracking susceptibility, there is currently not a defined method to "screen" materials in the same manner. Much of the data referenced for SCC susceptibility of metals is based on material SCC testing performed in a sodium chloride environment, not the propellant fluid. This test could help fulfill the requirements to qualify a metallic material in an environment similar to its intended use.

OUTCOME

- Slow strain rate tests were successfully performed on Ti-6Al-4V notched tensile specimens in the following environments: Air, 3.5%-NaCl solution, liquid phase of two oxidizers (MON-3, NTO)
- Test conditions were ambient laboratory temperature (73°F ± 5) and a strain rate of 1.5 x 10^{-6} in/s

Photos: Pre-test specimen (wstf2018e20280), slow strain rate test in progress (wstf2018e20273), PTFE environmental chamber designed and used for oxidizer exposure (wstf2018e20277)



- Consistent test results were achieved for all triplicate specimens tested
- No susceptibility to SCC was detected for the test conditions – as expected

FUTURE WORK

The next step to continue validating this test method for screening metallic material susceptibility to SCC is performing testing on Ti-6Al-4V specimens at higher temperatures (~165°F) where SCC is expected to occur in an NTO environment. Elevated temperature testing would require several design and safety considerations including a more robust, metallic environmental chamber to be designed and fabricated.