SUMMARY OF FINDINGS

This report is written to summarise the results of tests carried out in accordance with KNSI Test Plan Document No. 15K273-FR-001-0-R.

Aircraft interior composite components commonly incur damage that that includes (but not limited to) crushed/cracked skin, delamination/blistering on skin due to water ingress, impact damage and pulled inserts, delamination of skin on composite panels, chipped/scratched composite skin. It has long been established that adhesive bonding of these repairs offers major advantages for repairs of these components, avoiding fibre breaking and stress concentration as it does not require drilling of holes through the material.

Industry bonding adhesives currently used require a curing period of between five to twenty-eight days at room temperature. This in turn affects the aircraft downtime while the products are curing. We have included in some of the testing one such product, EA934 as a comparison.

SATTO products SA30-30 and SA30-40 have been developed to allow shorter curing times.

In aircraft airworthiness, it is important that a material or mechanical insert being used in aircraft structures, withstand a certain amount of load. This is governed by the load factor stated by FAA regulations and is an indication of the amount of load that the structure can withstand. To be conservative when calculating aircraft loads, it is necessary to use the ultimate inertial loads (i.e. from manoeuvring and performance limits) as they are the maximum loads that occurs in flight.

The purpose of the KNSI Test Plan/Report is to establish whether the SATTO products set out below are capable of withstanding the typical loads experienced by aircraft during operation.

- SATTO SA30-30
- SATTO SA30-40
- SATTO 10-10-7781

Full Test Reports are attached to this Summary.

Tensile Adhesion Results

In the FAA regulations (specifically FAR part 25.561) it is suggested that the ultimate inertial forces that the aircraft will experience are:

- Upward 3.0g
- Forward 9.0g
- Sideward 3.0g on airframe
- Downward 6.0g
- Rearward 1.5g

Where 'g' is the acceleration due to gravity. In order for the adhesive to be used as a potting adhesive, it is necessary that it must withstand the forces mentioned above. For example, an item of mass 'm' is installed into a honeycomb composite panel, it must withstand upwards forces and forward forces during flight to be certified. As suggested by the regulations (25.303) a safety factor of 1.5 must be used. Hence

$$F_{\text{upward}} = 1.5\ x\ m\ x\ 3.0g$$

$$F_{\text{forward}} = 1.5\ x\ m\ x\ 9.0g$$

As suggested from studies on honeycomb inserts, the forward load is not highly dependent on the adhesion of the potting compound to the core material, but to the skins of the sandwich composite panels. However, the upward force is highly dependent on the adhesion (shear strength) of the adhesive material.

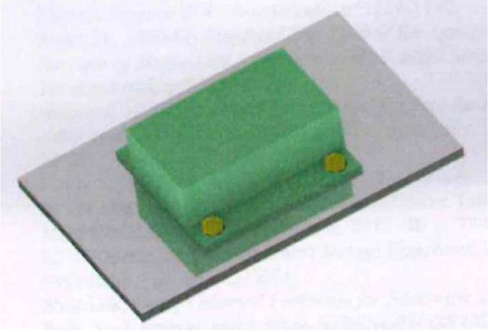
To be conservative in aircraft design, the first failure load value has been considered rather than skin failure. A simple calculation for airworthiness design can be conducted for a simple attachment with a mass of 20Kg show in the figure below. This item may be a fire hydrant that requires to be installed in an aircraft, or simply an avionics system that requires to be attached onto a honeycomb panel. Using the formula above, the total upward force:

$$F_{\text{upward}} = 1.5\ x\ 20\ x\ 3.0g$$

$$F_{\text{upward}} \approx 883N$$

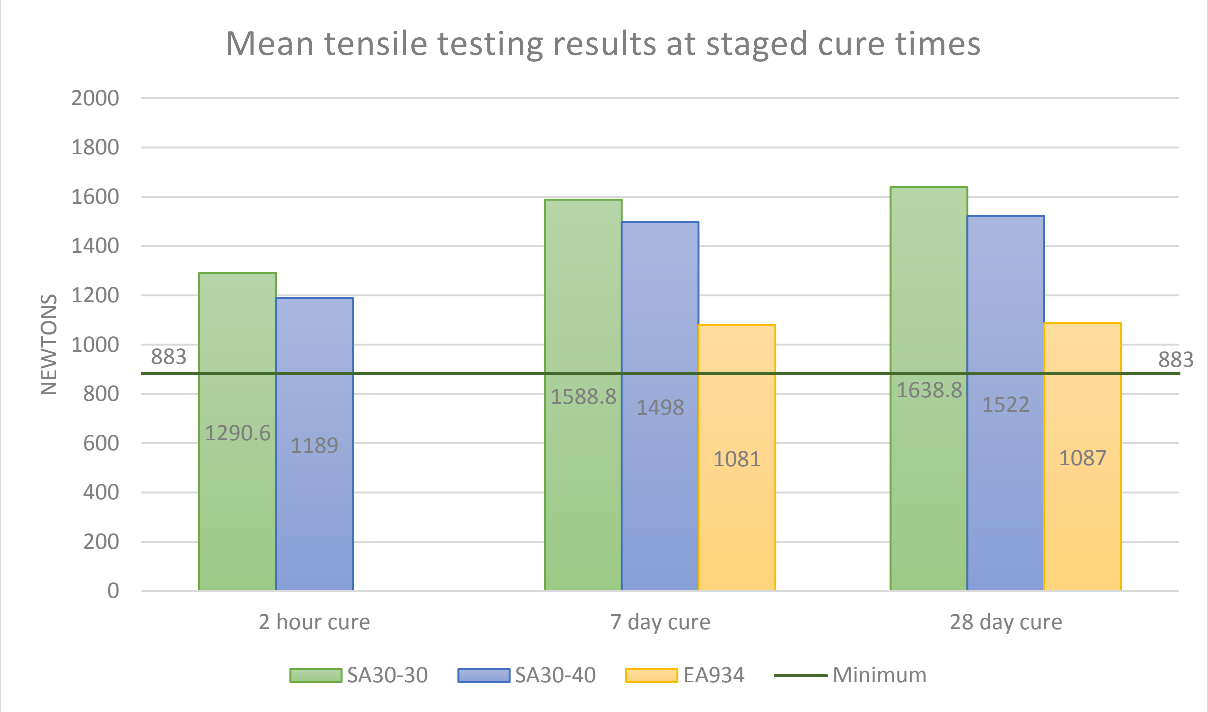
From the image (see below) in order to secure the item, four honeycomb inserts would be recommended to hold the item in place. From the results acquired from testing the total bonding strength:

$$Total\ Bonding\ Strength = 4\ x\ First\ Failure\ load.$$



Tests were carried out on SATTO SA30-30, SATTO SA30-40 and EA934 (as a strength and cure comparison) in order to determine the shear strengths of the repaired joints after a 2 hour curing period, 7-day curing period and 28-day curing period.

Airworthiness minimum for these tests is 883*N*.



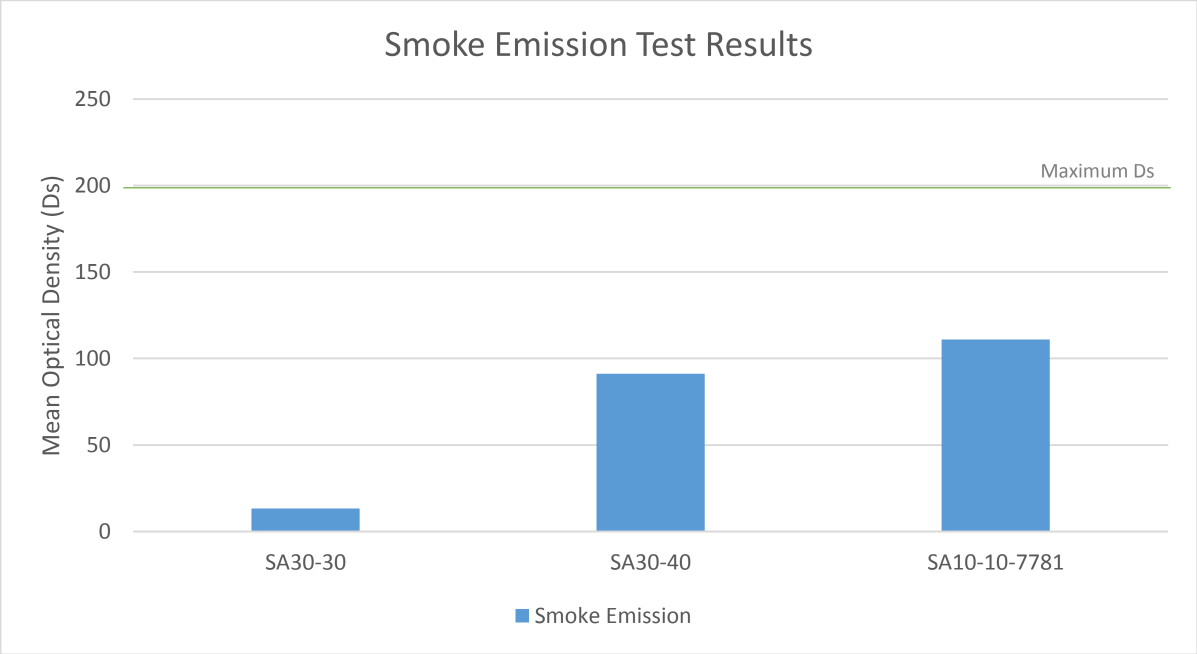
EA934 had not cured at the 2-hour test, so was not tested.

SATTO SA30-30 and SA30-40 clearly exceed airworthiness requirements after even a 2-hour cure.

Smoke Density Results

Tests were carried out on SATTO SA30-30, SATTO SA30-40 and SATTO SA10-10-7781 in order to determine the smoke density in flaming and non-flaming modes.

All three products passed the tests to the airworthiness specification.



Toxicity Test Results

Tests carried out on SATTO SA30-30, SATTO SA30-40 and SATTO SA10-10-7781 in order to determine the toxic gas emissions in flaming and non-flaming modes.

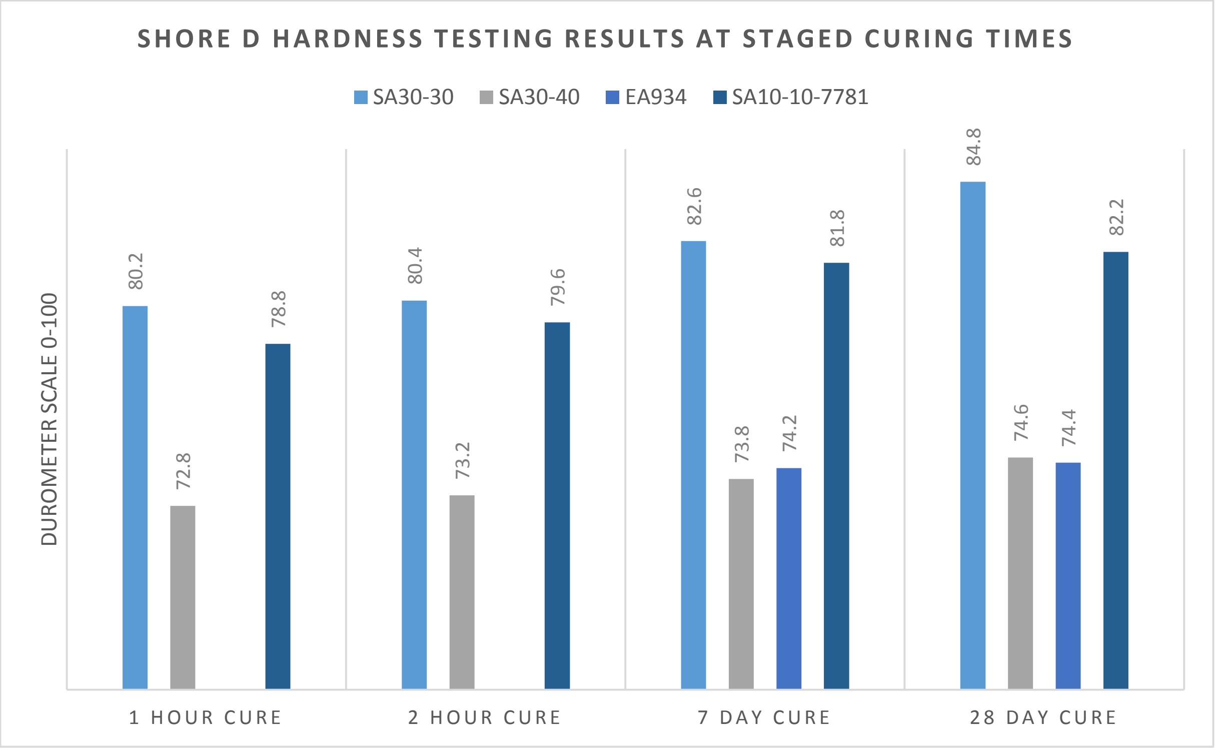
Toxic Gas Emission	SA30-30	SA30-40	SA10-10-7781	Maximum
CO (Flaming)	86	174	199	1000
HCN (Flaming)	1	1	2	150
HF (Flaming)	1.5	2	2	100
HCl (Flaming)	1	2	1	150
SO_2 (Flaming)	1	1	1	100
NO_x (Flaming)	4	1	2	100

All three products passed the tests to the airworthiness specification. These tests were carried out in combination with the Smoke Density Tests.

Hardness Test Results

The principle used to measure hardness is based on measuring the resistance force of the penetration of a pin into the test material under a known spring load. The amount of penetration (max. 2.5 mm) is converted to hardness reading on a scale with 100 units. Per the ASTM Standard D 2240, readings below 10 and above 90 are not to be considered reliable and should be discarded.

Shore D Hardness testing took place at 1 hour, 2 hours, 7 days and 28 days. EA934 had not cured before 7 days so was not tested.



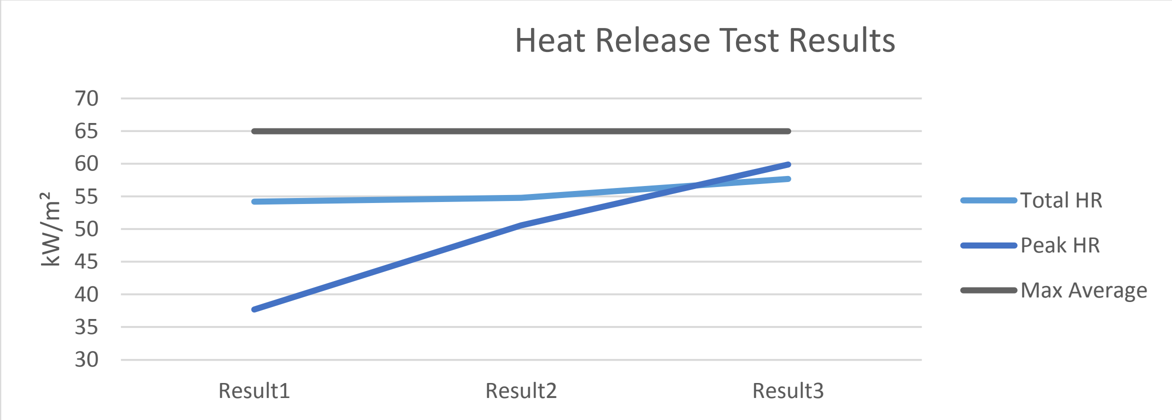
All four products passed the standards set in ASTM Standard D2240

Heat Release Test Results

Heat Release is a measure of the amount of heat energy evolved by a material when burned. It is expressed in terms of energy by unit area (kW min/m^2). Heat Release Rate (HRR) is a measure of the rate at which heat energy is evolved by a material when burned. It is expressed in terms of power per unit area (kW/m^2).

Results of the Heat Testing carried out in accordance with CS/FAA 25.853 App F Part IV:

TEST	Specification	Result1	Result2	Result3	Mean	Criteria	PASS/ FAIL
HEAT RELEASE CD25.853(d) Amdt 17 App.F PtIV(e)+(g)	Min Total HR (kWmin/m^2)	54.2	54.8	57.7	**55.5**	65(kWmin /m^2)	PASS
	Peak HR (kW/m^2)	37.7	50.6	59.9	**49.4**	65(kWmin /m^2)	



All three test pieces passed the Heat Release testing.

Vertical Burns Test Results

Interior components must be self-extinguishing when tested vertically in accordance with CS/FAA 25.853.

Results of the 60 second Vertical Burns Tests carried out in accordance with CS/FAA 25.853 App F Part 1(a)(1)(i):

SATTO Products	with	Test Length (seconds)	Flame (seconds)	Drip Flame (seconds)	Burn length (inches)	Test Certificate
SA30-30, SA30-40, SA10-10-7781	HD Nomex Core, Phenolic Glass, AF444, HSH1083	60	1.3	0	0.2	W60000025
SA30-30, SA30-40, SA10-10-7781	HD Nomex Core, Phenolic Glass, AF444, Jet Flex 09003-3-3, CM0110845, CM0981520	60	0.3	0	0.2	W60000024
SA30-30, SA30-40, SA10-10-7781	HD Nomex Core, Phenolic Glass, AF444, Mapaero FR45, FRS40, 1500FR	60	2.3	0	0.2	W60000023
SA30-30, SA30-40, SA10-10-7781	HD Nomex Core, Phenolic Glass, AF444, Mankiewiecz FST-346-57	60	1	0	0.2	W60000022
SA30-30, SA30-40, SA10-10-7781	HD Nomex Core, Phenolic Glass, AF444, Aertrim LW/18440	60	1.3	0	0.2	W60000021
SA30-30, SA30-40, SA10-10-7781	HD Nomex Core, Phenolic Glass, AF444, Aefilm LHR/12463	60	2.3	0	0.2	W60000020
SA30-30, SA30-40, SA10-10-7781	Nomex Core, Phenolic Glass, AF444, Aefilm LHR/12463	60	1	0	0.2	W60000019
SA30-30, SA30-40, SA10-10-7781	Nomex Core, Phenolic Glass, AF444, Aertrim LW/18440	60	1.7	0	0.2	W60000018
		Maximums	15	3	6	

Results of the 12 second Vertical Burns Tests carried out in accordance with CS/FAA 25.853 App F Part 1(a)(1)(ii):

SATTO Products	with	Test Length (seconds)	Flame (seconds)	Drip Flame (seconds)	Burn length (inches)	Test Certificate
SA30-30, SA30-40	Nomex Core, Phenolic Glass, AF444, Aerofilm LW18440	12	0.6	0	0.1	W60000017
SA30-30, SA30-40	Nomex Core, Phenolic Glass, AF444, Aerofilm LHR/12463	12	2.3	0	0.1	W60000016
SA30-30, SA30-40	Nomex Core, Phenolic Glass, AF444, Aerofilm LW/18440	12	1	0	0.1	W60000015
SA30-30, SA30-40	Nomex Core, Phenolic Glass, AF444, Aerofilm LHR/12463	12	6.6	0	0.1	W60000014
SA30-30	AF444, HSH 1083, Nomex Core, Phenolic Glass	12	5.6	0	0.1	W60000013
SA30-30	AF444, Jetflex 09003-3-3, CM0110845, CM0981520, Nomex Core, Phenolic Glass	12	5.3	0	0.1	W60000012
SA30-30	AF444, FR45, FR40, 1500FR, Nomex Core, Phenolic Glass	12	9.3	0	0.1	W60000011
SA30-40	AF444, FST-346-57, Nomex Core, Phenolic Glass	12	8.6	0	0.1	W60000010
		Maximums	15	5	8	

All specimens met the requirements of the standards.

Conclusion

One aim of airlines is to reduce the overhaul time of aircrafts in order to reduce aircraft maintenance costs. These results clearly demonstrate that SATTO SA30-30 and SA30-40 shows great potential for use as a structural adhesive for composite panels, and may indeed show a decrease in maintenance cost for airlines/MROs.

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