MACRO

A Materials Perspective on Fire Containment

19 October 2022

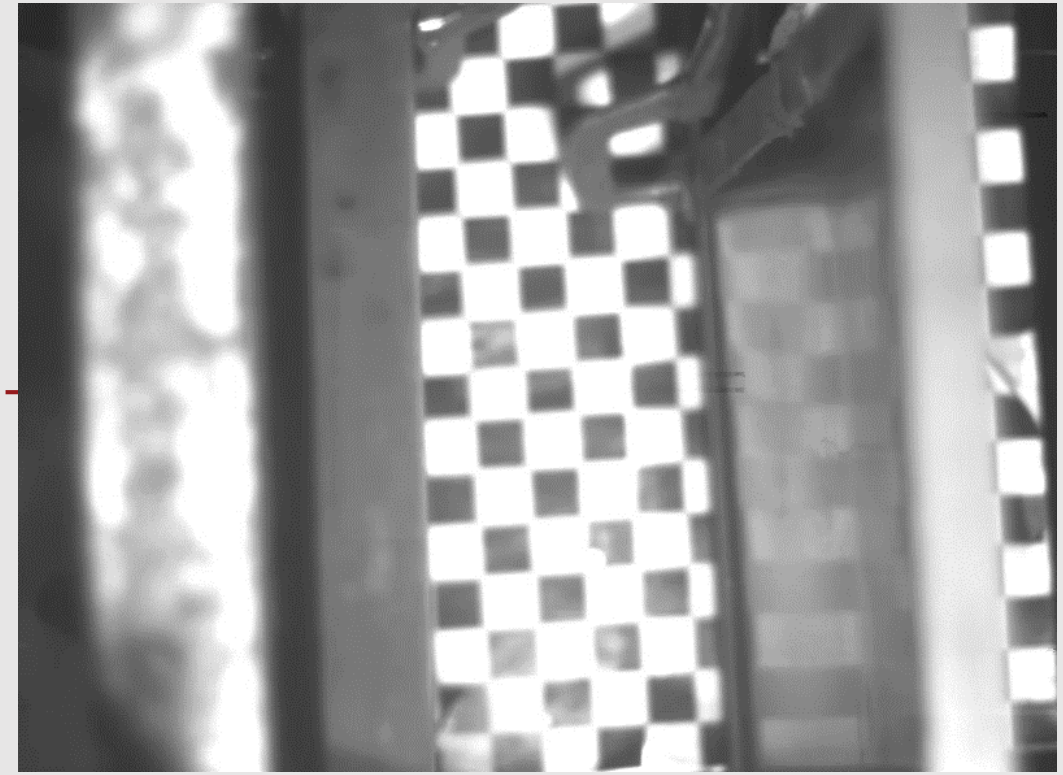
A Different Perspective

- MACRO is most known in this community for composite ULD skins
  - MACRO is also engineering services company that solves problems with custom materials
  - Started with aircraft armor in late-1990's, before adapting material systems for the rail industry (high-abrasion wear pads), then into ULD's skins and EV / battery enclosures
- A cross-market view, solely focused on custom material products brings a unique perspective
  - Our military products are governed by strict specifications and subject to steadily increasing protection levels with each passing year and program
- By contrast, FRC ULD's are relatively early in specification development – we now have a baseline, but the materials and engineering can do more given the right goals

A Different Perspective

Challenge is that of a “catchers’ mitt,” reacting the impacting energy (20K Joules) over a set distance in a controllable manner

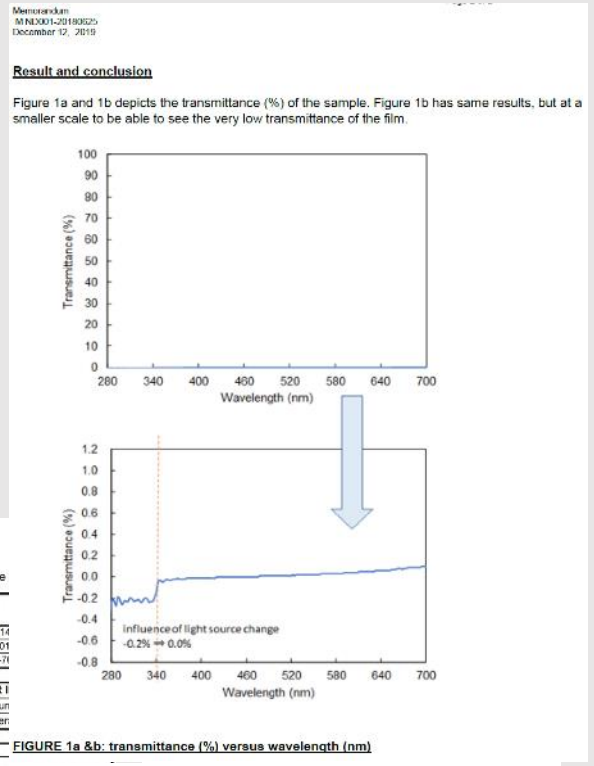
.50 Caliber



From a materials perspective, stopping a bullet and stopping a ULD fire are similar – they require only understanding of energy reaction and use of engineered “counter measures” that take advantage of how the materials react, interact, and fail

Materials Design Philosophy

- MACRO's material focus has always been maximizing protection and continually improving our offerings
  - High technical fiber content and multi-functional materials
  - Full Scale vs 5 vs 15-minute Part III Cargo-Liner Oil Burner Test
  - Life rated dual-films with zero UV transmittance and bright, durable interior
  - End of Life Recyclability / Sustainability goals



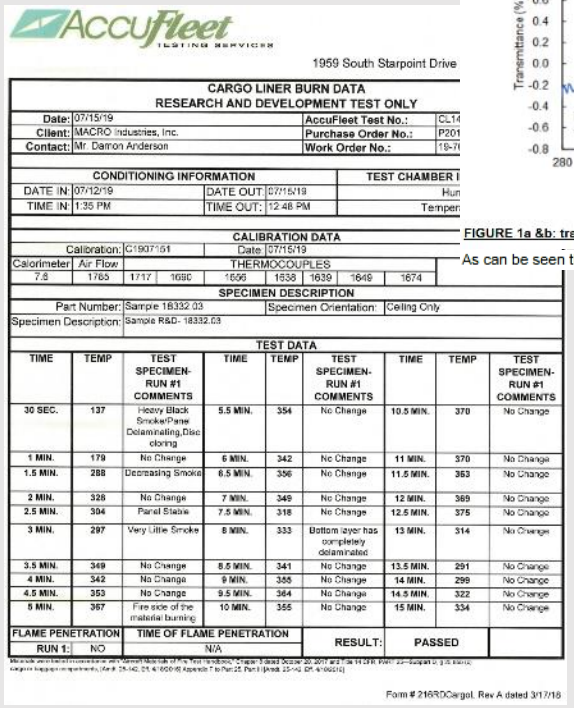
Memorandum
MM0001-20190925
December 12, 2019

Result and conclusion

Figure 1a and 1b depicts the transmittance (%) of the sample. Figure 1b has same results, but at a smaller scale to be able to see the very low transmittance of the film.

FIGURE 1a &b: transmittance (%) versus wavelength (nm)

As can be seen the film has almost no transmittance in the UV and visible wavelengths.



AccuFleet TESTING SERVICES

1959 South Starpoint Drive

CARGO LINER BURN DATA
RESEARCH AND DEVELOPMENT TEST ONLY

Date:	07/15/19	AccuFleet Test No.:	CL1
Client:	MACRO Industries, Inc.	Purchase Order No.:	P201
Contact:	Mr. Damon Anderson	Work Order No.:	19-7

CONDITIONING INFORMATION				TEST CHAMBER I
DATE IN:	07/12/19	DATE OUT:	07/15/19	Hum
TIME IN:	1:35 PM	TIME OUT:	12:48 PM	Temper

CALIBRATION DATA

Calibration:	C1907161	Date	07/15/19					
Calorimeter	Air Flow	THERMOCOUPLES						
7.8	1765	1717	1690	1696	1638	1639	1649	1674

SPECIMEN DESCRIPTION

Part Number:	Sample 18332.03	Specimen Orientation:	Ceiling Only
Specimen Description:	Sample R&D- 18332.03		

TEST DATA

TIME	TEMP	TEST SPECIMEN-RUN #1 COMMENTS	TIME	TEMP	TEST SPECIMEN-RUN #1 COMMENTS	TIME	TEMP	TEST SPECIMEN-RUN #1 COMMENTS
30 SEC.	137	Heavy Black Smoke/Panel Delaminating,Discoloring	5.5 MIN.	354	No Change	10.5 MIN.	370	No Change
1 MIN.	179	No Change	6 MIN.	342	No Change	11 MIN.	370	No Change
1.5 MIN.	288	Decreasing Smoke	6.5 MIN.	356	No Change	11.5 MIN.	363	No Change
2 MIN.	328	No Change	7 MIN.	349	No Change	12 MIN.	369	No Change
2.5 MIN.	304	Panel Stable	7.5 MIN.	318	No Change	12.5 MIN.	375	No Change
3 MIN.	297	Very Little Smoke	8 MIN.	333	Bottom layer has completely delaminated	13 MIN.	314	No Change
3.5 MIN.	349	No Change	8.5 MIN.	341	No Change	13.5 MIN.	291	No Change
4 MIN.	342	No Change	9 MIN.	355	No Change	14 MIN.	299	No Change
4.5 MIN.	353	No Change	9.5 MIN.	364	No Change	14.5 MIN.	322	No Change
5 MIN.	367	Fire side of the material burning	10 MIN.	355	No Change	15 MIN.	334	No Change

FLAME PENETRATION		TIME OF FLAME PENETRATION	RESULT:	PASSED	
RUN 1:	NO	N/A			

Form # 216RDCargoL Rev A dated 3/17/16

A Different Perspective

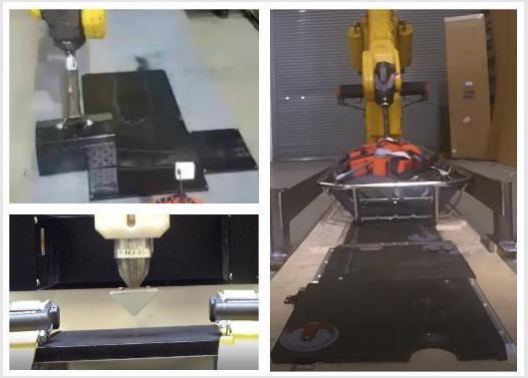
Flammable materials and low-melt temperatures pass → *Melt temp matters, some metals & non-flammable materials begin to fail* → *Flame protection becomes discretized, requiring distinct, separate defeat mechanisms* → *Requires a total system / materials view*

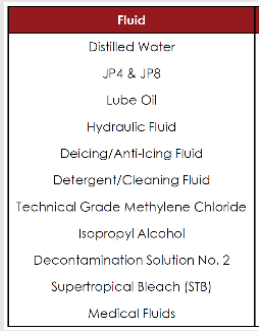
Fires are all different in their lethality, just like armor protection levels vary greatly

Different materials pass or fail each of these sub-component tests in different ways

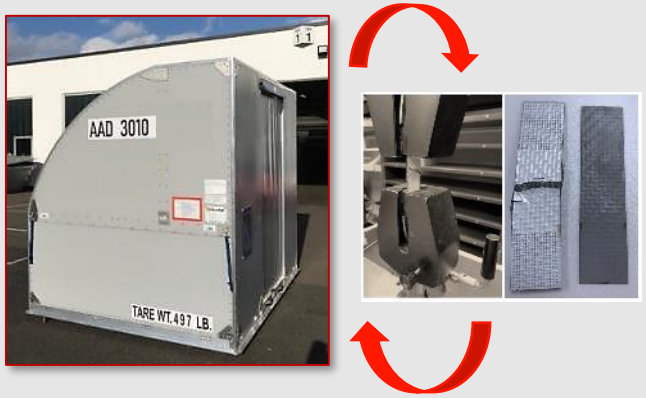
Each also indicates different behaviors in full-scale, integrated product fire-testing

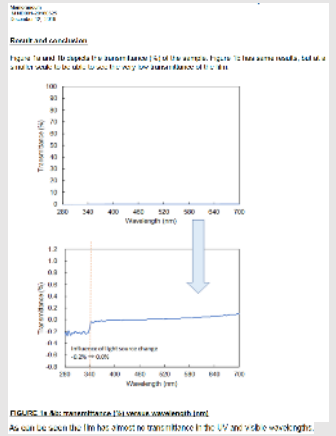
Materials Design – Day 3650





ISO / ASTM Material Aging Tests

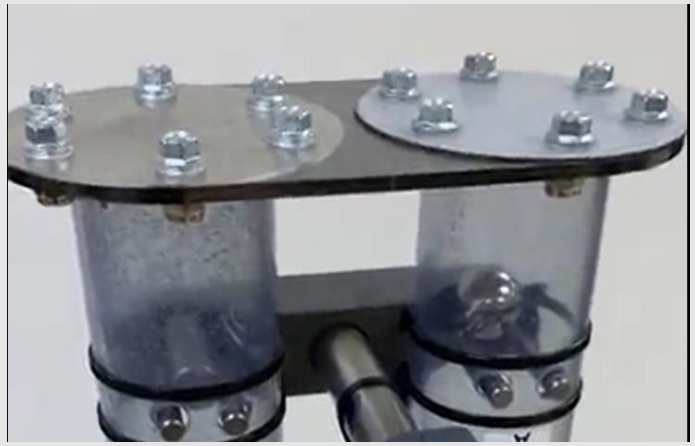


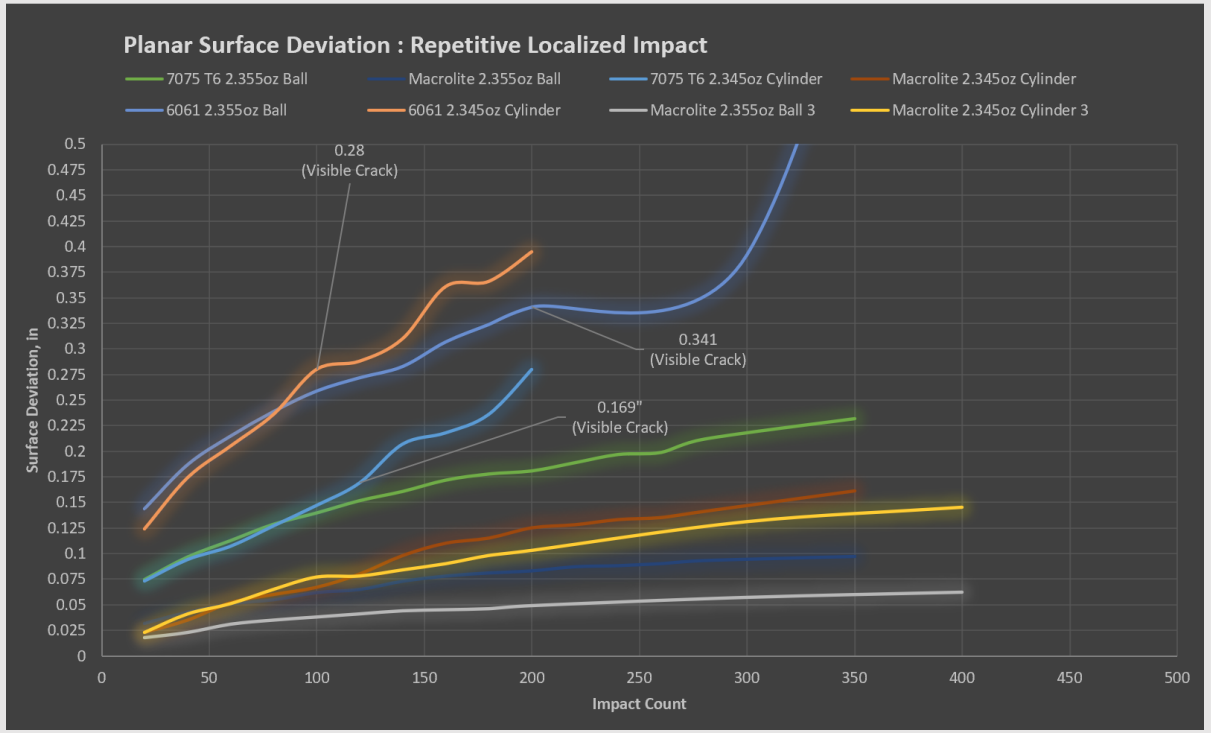


Internal "induced damage" and performance at temperature tests

Safety Equipment should be designed for sustained performance, not evaluated on Day 1 – There are too few requirements around longevity

Materials Design – Day 3650





One way that MACRO “ages” materials to simulate residual flame resistance well into service life is through repeated, low-level cyclical impacts (2.355 ounce / 1J cylinder & sphere repeatedly impact materials being compared, followed by flame resistance testing)

Final Thoughts – Standards and Iteration

- Tiered standards are an opportunity for the ULD community
  - MACRO's military programs regularly publish simultaneous baseline, threshold and objective requirements, eventually procuring to the highest level available and/or as required for specific missions
  - Standards for safety equipment could mirror this philosophy, differentiating energy capability (rather than specific fire load), given that threats change, all users have a different risk profile, and mission profiles change over the life of the aircraft / equipment
- Materials, FRC ULD's, and fire-safety products in general will continually improve if we design our regulatory framework around multi-step stretch goals, allow products to differentiate based on energy levels, and value iterative improvement as an industry

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Questions? Contact Dan Ziegler @ dan.ziegler@macroindustries.com

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