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Evaluation of Microcare Tergo HDF and XCF3 as Maintenance Cleaners Prior to Fluorescent Penetrant Inspection (FPI)

by Scott Grendahl

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14. ABSTRACT
The U.S. Army Aviation and Missile Command's Environmental Division (G-4) requested that ARL's Biology, Materials, and Manufacturing Sciences Division evaluate Microcare Tergo HDF and XCF3 as maintenance cleaning solvents for use prior to fluorescent penetrant inspection. The results demonstrated that both products outperformed the standard comparative, methyl ethyl ketone (MEK). Both products should now be reviewed by the final approval authority for use in the maintenance and overhaul processes at Army depots and airfields.

15. SUBJECT TERMS
fluorescent penetrant inspection, FPI, solvent cleaning, maintenance chemical, crack indications, methyl ethyl ketone, MEK

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1. Objective

The objective of the testing was to evaluate the effectiveness of Microcare Tergo HDF and XCF3 as a vapor degreasing cleaner prior to Fluorescent Penetrant Inspection (FPI), as requested by the U.S. Army Aviation and Missile Command's (AMCOM's) Environmental Division (G-4). This evaluation was conducted under the guidelines of MIL-PRF-32684, Section 3.9.5.[1] Methyl ethyl ketone (MEK) was used as a control cleaning agent for comparison.

2. Materials and Methods

2.1 Test Solutions

- MEK (standard control cleaner)
- Microcare Tergo HDF
- Microcare XCF3

2.2 Test Specimens

Three fatigue precracked test bars were used:

- R70: Inconel 718 (precrack ~0.090-inch L × 0.020-inch D × 0.001-inch W)
- R91: Inconel 718 (precrack ~0.020-inch L × 0.005-inch D × 0.001-inch W)
- T62: Ti 6-4 (precrack ~0.060-inch L × 0.017-inch D × 0.0005-inch W)

2.3 Equipment

- UV Measurement:
  - Photo Research Photomultiplier-Tube Optical Photometer Model UBD PR-1500 Spectra Spotmeter
  - Spectroline Model SB-100 Super High Intensity UV Lamp (10K+ μW/cm²)
  - Spectroline Model DSE-100X Photometer with Spectroline Model DIX-365 UV-A sensor
- Cleaning Apparatus: a refluxing apparatus for vapor degreasing simulation, as depicted in Figure 1.

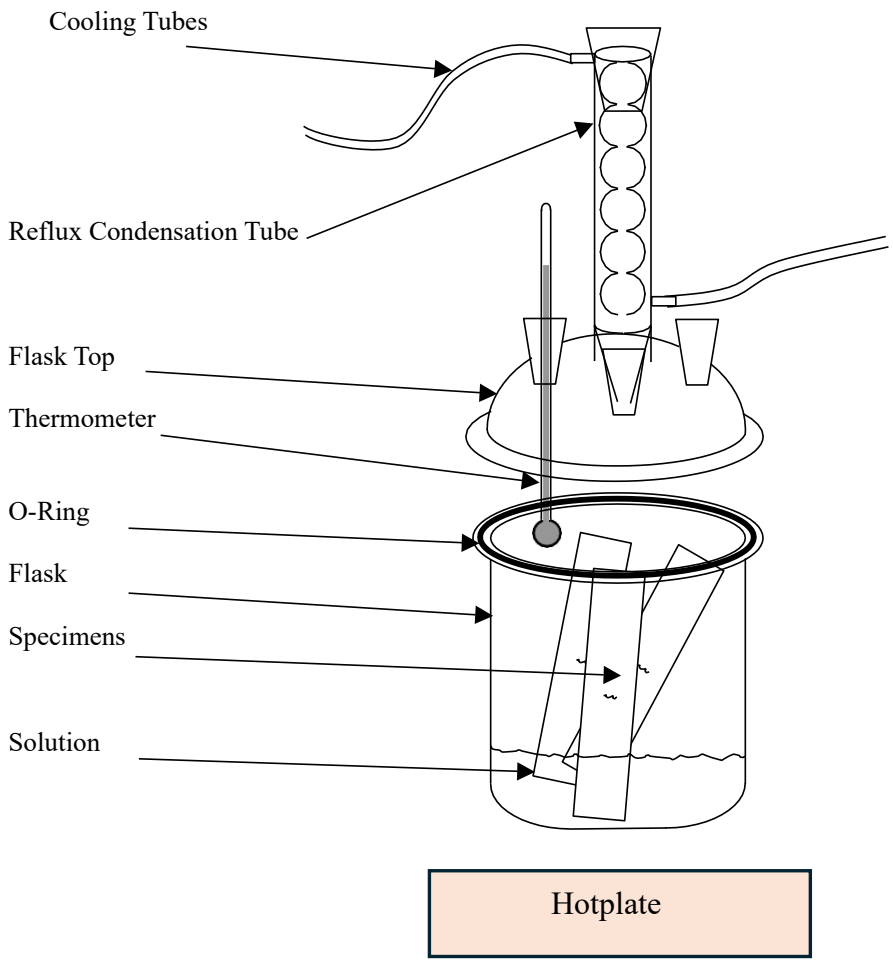

Figure 1. Schematic of test cleaning apparatus.

2.4 Procedure

The test cleaning procedure simulated vapor degreasing using a 10-min cleaning cycle. The steps were as follows:

1) Pre-clean with MEK solvent control cleaner.
2) Apply a standard contaminant mixture (hydraulic fluid, MoS_2 grease, carbon black) to the crack area and bake at 130 °F.
3) Wipe off excess contaminant with a clean towel.
4) Perform solvent cleaning in the test fluid for one 10-min cycle.
5) Cool the specimen to room temperature.
6) Apply Type I, Method C, Sensitivity Level 4 penetrant to the crack area with a dwell time of 5 min.
7) Wipe off excess penetrant with a dry, lint-free cloth.
8) Perform a solvent wipe with a lint-free cloth.
9) Apply Form A, Dry Powder developer with a dwell time of 5 min.

10) Perform quantitative brightness measurement with a light meter, using a standardized angle of incidence, standoff, and UV light intensity (10K+ μW/cm²).
11) Postclean with a deionized (DI) water rinse.
12) Postclean with an aqueous cleaner followed by a hot DI rinse.
13) Postclean with the MEK vapor degreasing simulator for a 10-min cycle.
14) Repeat steps 1–13 for each test fluid and specimen across three test runs with each test specimen.

3. Results

The brightness of the fluorescent indications was measured quantitatively with the apparatus listed. The collected data are summarized in Tables 1 and 2. Representative photographs are depicted below for comparison with each test specimen in Figures 2, 3, and 4, respectively, for specimens R91, R70, and T62.

Table 1. Measured brightness data.

Solvent cleaner	Specimen no.	Test run no.	Spot meter reading	Background reading	Total brightness of indication
MEK	R 91	1	62.9	0.02	62.88
	R 70	1	389	0.04	388.96
	T 62	1	79.6	0.01	79.59
HDF	R 91	1	70.2	0.03	72.17
	R 70	1	381	0.05	380.95
	T 62	1	82.6	0.04	82.56
XCF3	R 91	1	69.8	0.03	69.77
	R 70	1	385	0.01	384.99
	T 62	1	84.6	0.02	84.58
MEK	R 91	2	65.4	0.02	65.38
	R 70	2	348	0.05	347.95
	T 62	2	77.4	0.04	77.36
HDF	R 91	2	66.4	0.02	66.38
	R 70	2	388	0.01	387.99
	T 62	2	75.8	0.03	75.77
XCF3	R 91	2	66.5	0.04	66.46
	R 70	2	391	0.02	390.98
	T 62	2	79.1	0.03	79.07
MEK	R 91	3	68.8	0.01	68.79
	R 70	3	339	0.03	338.97
	T 62	3	75.6	0.02	75.58
HDF	R 91	3	74.3	0.02	74.28
	R 70	3	372	0.03	371.97
	T 62	3	80.6	0.01	80.59
XCF3	R 91	3	68.6	0.03	68.57
	R 70	3	375	0.03	374.97
	T 62	3	74.1	0.01	74.09

Table 2. Scaled effectiveness.

Specimen no.	Average brightness (three measurements)	Scaled effectiveness (MEK = 100%)
MEK with R91	65.7	100
MEK with R70	358.66	100
MEK with T62	77.53	100
HDF with R91	70.3	107
HDF with R70	380.33	106
HDF with T62	79.67	102.8
XCF3 with R91	68.3	104
XCF3 with R70	383.67	107
XCF3 with T62	79.27	102.2

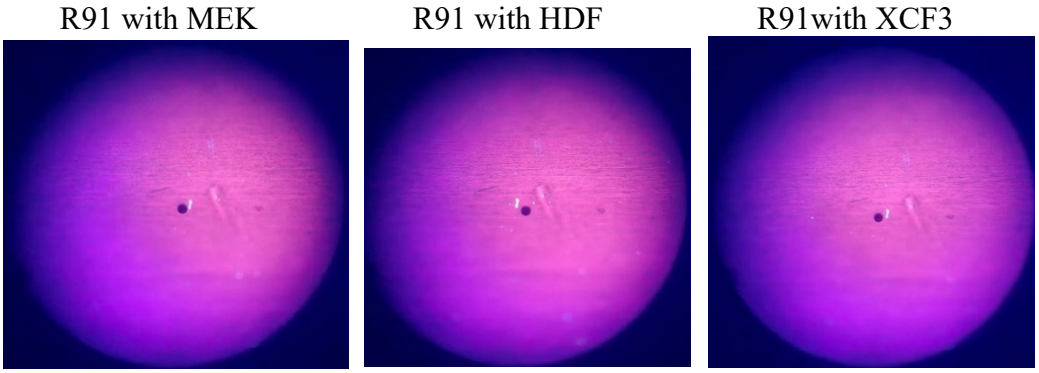

Figure 2. MEK, HDF, and XCF3 representative indications on R91.

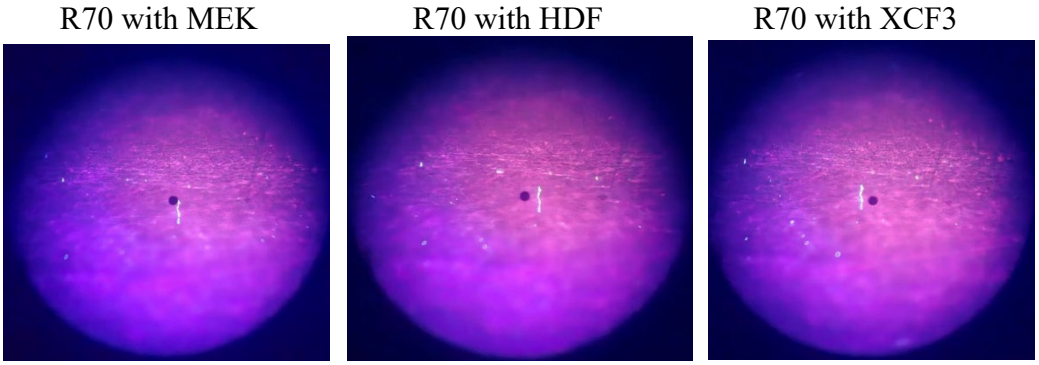

Figure 3. MEK, HDF, and XCF3 representative indications on R70.

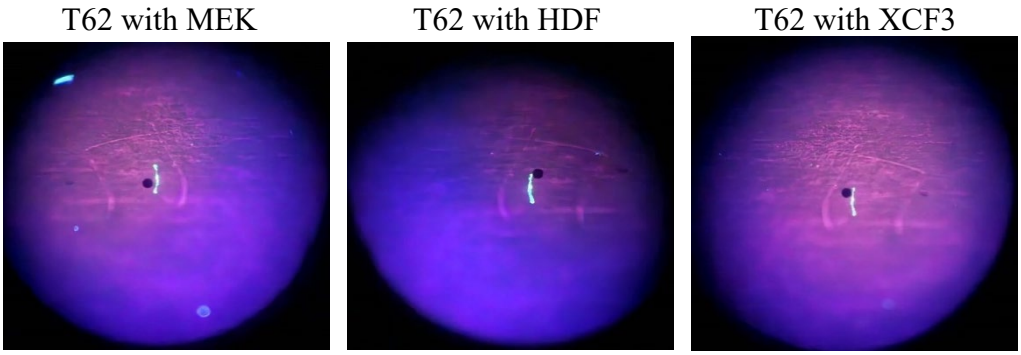

Figure 4. MEK, HDF, and XCF3 representative indications on T62.

4. Discussion and Conclusion

The photometer provides a quantitative number to the UV brightness under the black dot in the representative photos while in "spot mode." Note that these indications (i.e., cracks) in the photos are only 20 mil long and this equipment was not designed for photography, as the depth of field (i.e., the focal plane of the lens) is very small. In comparison with the MEK, HDF appears to be on average, approximately 105% as effective as MEK as a pre-FPI cleaning solvent, while XCF3 was found to be 104% as effective. The U.S. Army Combat Capabilities Development Command Army Research Laboratory's Biology, Materials, and Manufacturing Sciences Division has observed similar trends in the past with alternative solvents. For some individual tests, MEK outperformed the candidate solvent; however, the alternative was equally effective for the most part. In the past, n-propyl bromide (nPB) alternative solvent was deemed acceptable for vapor degreasing prior to FPI inspection by AMCOM. The comparative study was similar and the results for nPB were lower in comparison with MEK and the test solvent candidates used in this evaluation. Furthermore, nPB proved 85% as effective as MEK, while here both solvents were more effective. This was a small-scale study; however, the solvent could be expected to perform as well as the current cleaning solvents in the overhaul and maintenance cycles. The background is much less bright (a good thing) than that observed when using aqueous cleaners and the total brightness was higher in magnitude than that yielded with aqueous cleaners in previous studies. This is subjective, as they were not directly compared here. It can be seen in the representative photos that a low background reading is conducive to good contrast between the indication (a crack) and the intact base material that surrounds it.

5. References

1. MIL-PRF-32684. Vapor degreasing solvent. Army (US); 2022 Aug 26.

List of Symbols, Abbreviations, and Acronyms

AMCOM	U.S. Army Aviation and Missile Command
DI	Deionized
FPI	Fluorescent Penetrant Inspection
MEK	Methyl Ethyl Ketone
nPB	n-Propyl Bromide
UV	Ultraviolet

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