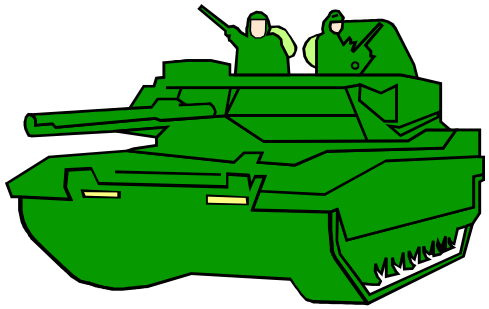
CAN COMMERCIALLY AVAILABLE BIO-BASED HYDRAULIC FLUIDS MAKE THE GRADE FOR THE ARMY?
Part II



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Brief

- Who's Involved?
- Project Mission
- Military Specifications
- Project Overview
  - Phase I, Phase II, Phase III
- Data
- Conclusions

Who's Involved?

- Concurrent Technologies Corporation (CTC)
- Fuels and Lubricants Technology Team (FLTT)
- Southwest Research Institute (SwRI)

Environmental Mission

- To determine if commercially available, biodegradable, bio-based hydraulic fluids can achieve or exceed current military specifications, MIL-PRF-6083 or MIL-PRF-46170

Military Specif

Properties	MIL-PRF-6083	MIL-PRF-46170
Base Material	Petroleum-based fluid	Synthetic Hydrocarbon-based fluid (PAO)
Low temp properties	Excellent low temperature properties	Fair low temperature properties
Biodegradability	Not readily biodegradable	Class II biodegradable
Flash point	Low Flash Point (82°C)	High flash point (218°C)
Flammability	Flammable	Fire resistant
Corrosion protection	Rust Inhibited	Rust inhibited

How Can Bio-Based Fluids Inf

- Uses renewable sources
- Biodegradable
- Provides domestic market for agricultural products

What are the Benef Drawbacks to Bio-Based Hydraulic Fluids?

- Benefits
  - Biodegradable
  - Good lubricity
  - Uses renewable sources
- Drawbacks
  - Poor low temperature properties / stability
  - Less than ideal thermal stability (oxidation)
  - Poor fire resistance properties
  - Poor Rust Protection

Project Overview

- Phase I – Market Survey / Initial Screening
- Phase II – In-Depth Laboratory Evaluation
- Phase III – Field Demonstration

Phase I

- 16 samples submitted by 11 companies
- Screening performed by FLTT and SwRI
- Tests performed:
  - Viscosity
  - Pour Point
  - Flash Point
  - Fire Point
  - TAN and TBN
  - Lubricity (4 Ball Wear)
- None of the candidate fluids met all requirements

Phase I Data

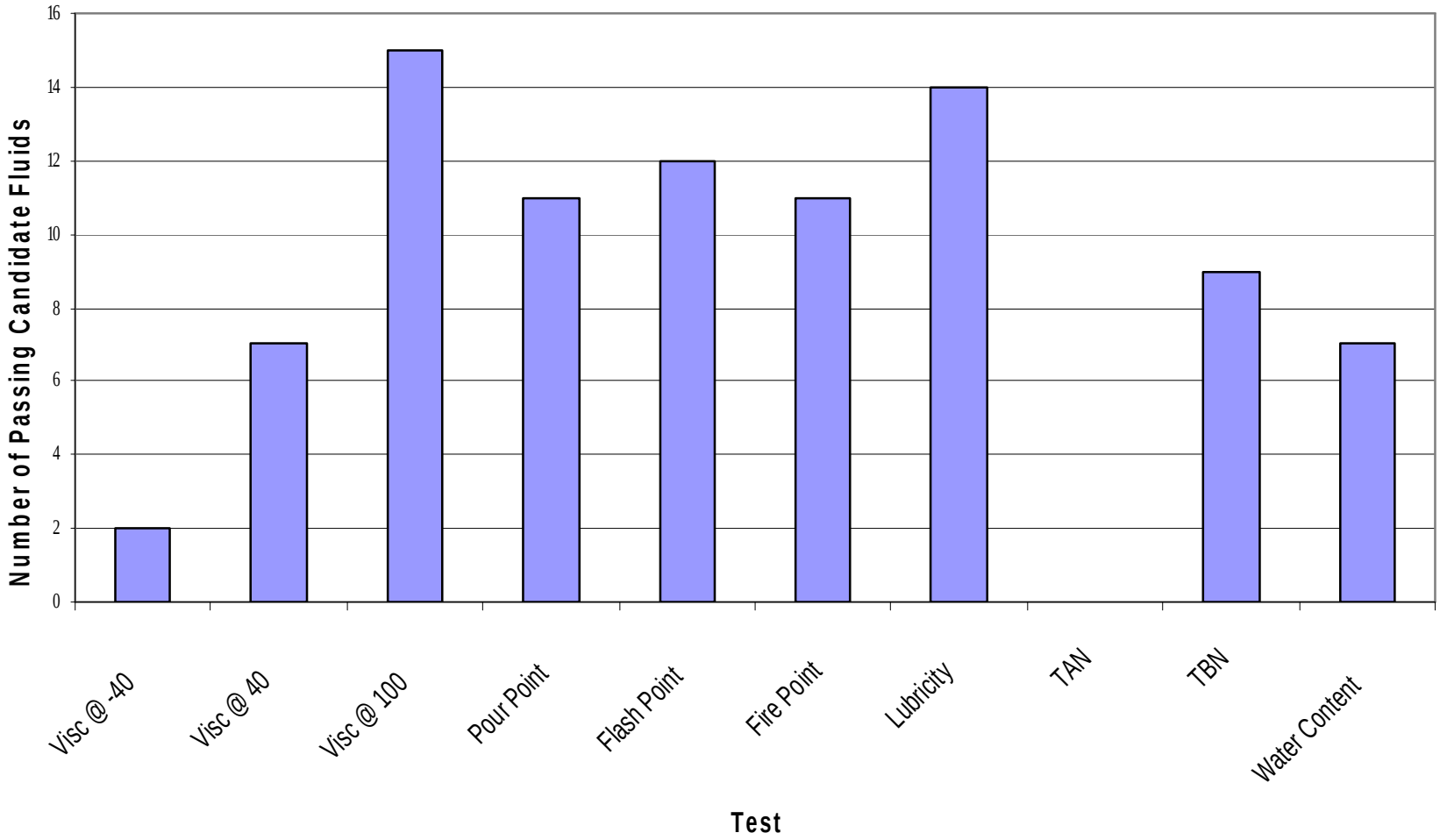
	Visc -40 ?C (cSt)	Visc 40 ?C (cSt)	Visc 100 ?C (cSt)		Pour Point (?C)		Flash Point (?C)	Fire Point (?C)	Lubricity (mm)	TAN (mgKOH /g)	TBN (mgKOH /g	Water Content (%)
	SwRI	FLTT	FLTT	SwRI	FLTT	SwRI	SwRI	SwRI	SwRI	SwRI	SwRI	FLTT
A	4212	19.35	5.075	5.07	-58.5	-43	233	238	0.43	0.75	0.69	0.038
B	15107	41.92	5.32	5.27	-55.5	-47	252	288	0.45	0.49	0.15	>0.1
C	35009	24.6	8.292	8.1	-66	-44	269	302	0.43	0.38	0.12	0.094
D	3039	19.11	4.513	4.55	-66	-44	202	222	0.43	0.73	0.26	0.054
E	TVTM	45.06	7.898	7.87	-43.5	-21	291	324	0.44	0.51	0.26	0.038
F	1687	16.78	4.464	4.47	-69	>-50	158	161	0.43	0.55	0.26	0.068
G	4075	17.33	4.089	4.11	-66	-45	252	263	0.48	1.09	no TBN	0.08
H	7060	20.42	4.47	4.43	-63	>-50	272	294	0.5	1.09	no TBN	0.098
I	8529	26.46	5.474	5.55	-60	>-50	227	274	0.65	0.34	0.04	>0.079
J	TVTM	46.17	9.755	9.82	-33	-21	321	349	0.4	1.34	0.5	0.038
K	TVTM	65.2	13.36	13.6	-29	-23	263	283	0.42	0.91	0.37	0.044
L	TVTM	26.94	5.693	5.65	-48	-39	240	257	0.47	1.83	0.28	0.035
M	TVTM	17.19	4.122	4.14	-63	-40	224	255	0.89	0.38	no TBN	0.092
N	3811	17.42	4.186	4.15	-63	-43	230	258	0.93	0.25	no TBN	0.07
O	TVTM	31.75	7.395	7.46	-43.5	-35	205	230	0.4	0.53	no TBN	0.04
P	720	9.37	2.839	2.85	-68	-43	166	180	0.35	0.22	no TBN	0.01

Pink = Fails to meet specification for MIL-PRF-46170

Orange = Fails to meet specification for MIL-PRF-6083

Red = Fails to meet either specification, 46170 or 6083

Number of Passing Candidate Fluids for Each Test



Phase II

- All Phase I manufacturers were given the opportunity to reformulate their fluids
- 10 new candidate fluids were submitted by 7 manufacturers (one of the samples was only submitted to SwRI)
- Repeated Phase I laboratory tests plus 3 additional tests

Phase II Data

	Visc -40°C (cSt)		Visc 40°C (cSt)	Visc 100°C (cSt)		Pour Point (°C)		Flash Point (°C)	Fire Point (°C)	Lubricity	TAN		TBN	Water Content (%)	Bimetallic Couple	Rust Protection	Low Temp Stability	
	FLTT	SwRI	FLTT	FLTT	SwRI	FLTT	SwRI	SwRI	SwRI	FLTT	FLTT	SwRI	SwRI	FLTT	FLTT	FLTT	FLTT	
A	2407.9	2425.7	17.77	4.780	4.78	Pass	-54	204	234	0.389	1.67	1.44	0.1	0.0611	Pass	Fail	Pass	Fail
B	6116.5	6478.9	24.84	4.85	4.76	Pass	-63	186	262	0.529	0.249	0.28	no TBN	0.1521	Pass	Fail	Pass	Fail
C	TVTM	7574.7	22.65	6.33	6.32	Fail	-45	237	252	0.356	0.222	0.39	no TBN	0.0116	Pass	Pass	Fail	Fail
D	1980.8	2876.7	13.23	3.57	3.57	Pass	-63	216	238	0.359	0.379	0.5	no TBN	0.0675	Pass	Fail	Fail	Fail
E	2705.6	4084.9	14.61	3.81	3.82	Fail	-60	222	243	0.431	0.413	0.57	no TBN	0.1148	Pass	Fail	Fail	Fail
F	2362.8	2298.6	14.24	3.63	3.63	Pass	-66	226	245	0.392	0.399	0.55	no TBN	0.0972	Pass	Fail	Fail	Fail
G	2311.1	2268.8	13.69	3.49	3.50	Pass	-66	177	191	0.403	0.172	0.39	no TBN	0.0447	Pass	Fail	Pass	Fail
H	3511.0	3227.4	15.78	3.89	3.85	Pass	-63	226	252	0.427	0.166	0.11	no TBN	0.0600	Pass	Fail	Fail	Fail
I	2765.0	2586.4	13.55	3.58	3.53	Pass	-72	229	239	0.297	0.602	0.6	0.03	0.0737	Pass	Pass	Fail	Fail
J	not tested	2902.0	not tested	not tested	2.94	not tested	-66	193	212	not tested	not tested	0.36	0.03	not tested	not tested	not tested	not tested	

Pink = Fails to meet specification for MIL-PRF-46170

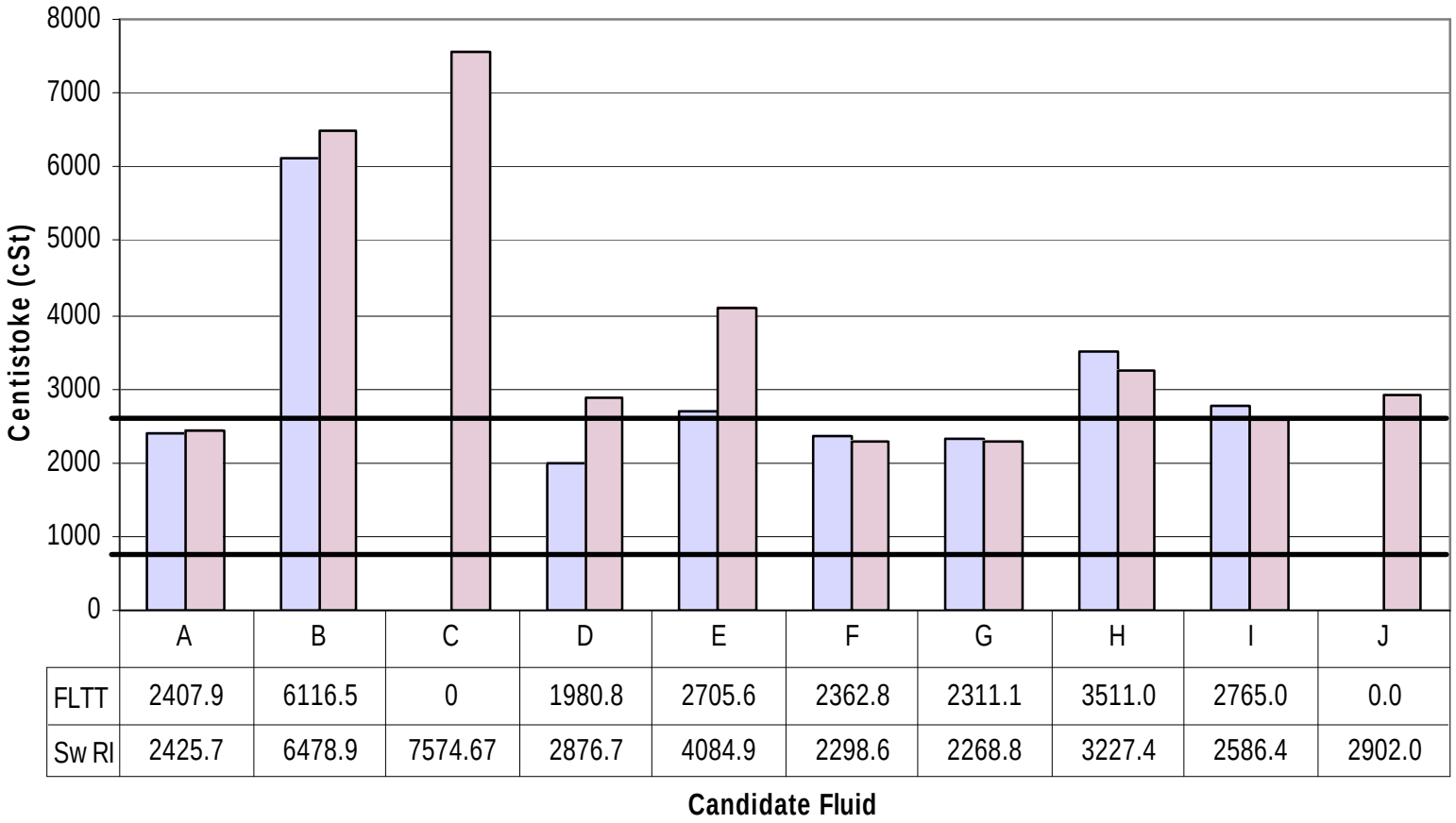
Orange = Fails to meet specification for MIL-PRF-6083

Red = Fails to meet either specification, 46170 or 6083

Phase II (cont)

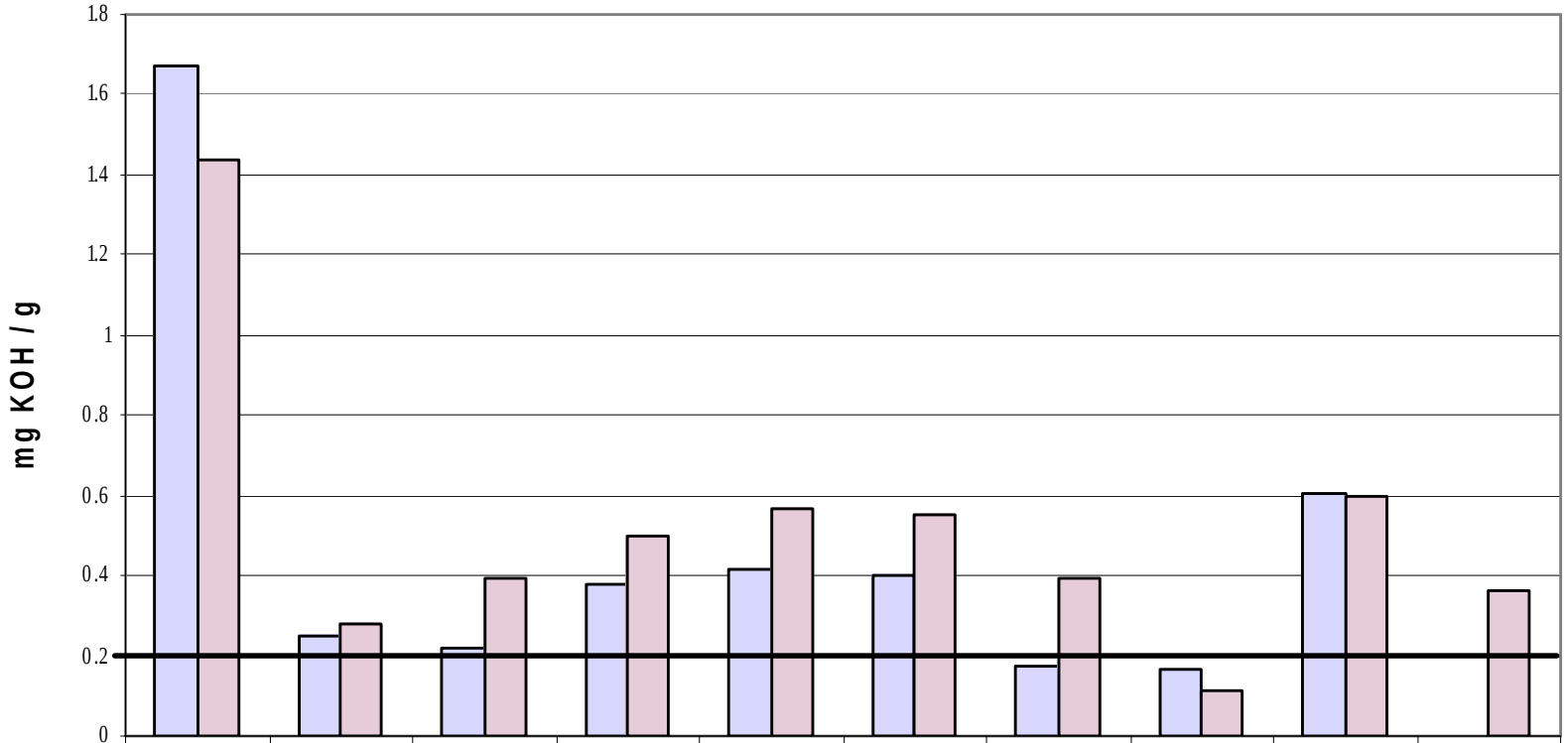
- None of the candidate fluids met all of the requirements
- Trouble properties:
  - -40°C Viscosity
  - TAN
  - Water Content
  - Rust Protection
  - Low Temperature Stability

Viscosity @ -40 deg Celsius



	A	B	C	D	E	F	G	H	I	J
FLTT	2407.9	6116.5	0	1980.8	2705.6	2362.8	2311.1	3511.0	2765.0	0.0
Sw RI	2425.7	6478.9	7574.67	2876.7	4084.9	2298.6	2268.8	3227.4	2586.4	2902.0

Total Acid Number

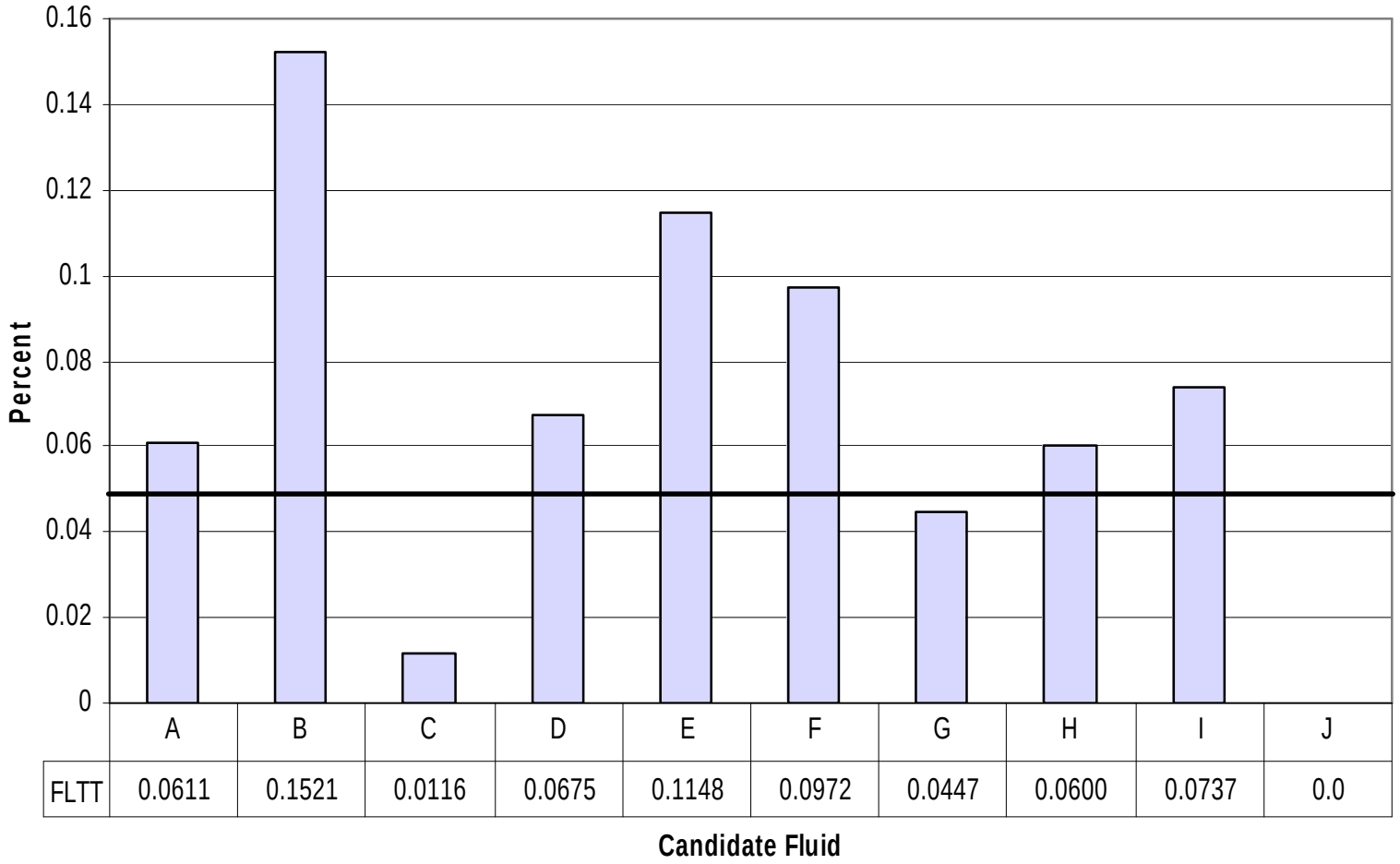


	A	B	C	D	E	F	G	H	I	J
FLTT	1.67	0.249	0.222	0.379	0.413	0.399	0.172	0.166	0.602	0.0
Sw RI	1.44	0.28	0.39	0.5	0.57	0.55	0.39	0.11	0.6	0.36

Candidate Fluid

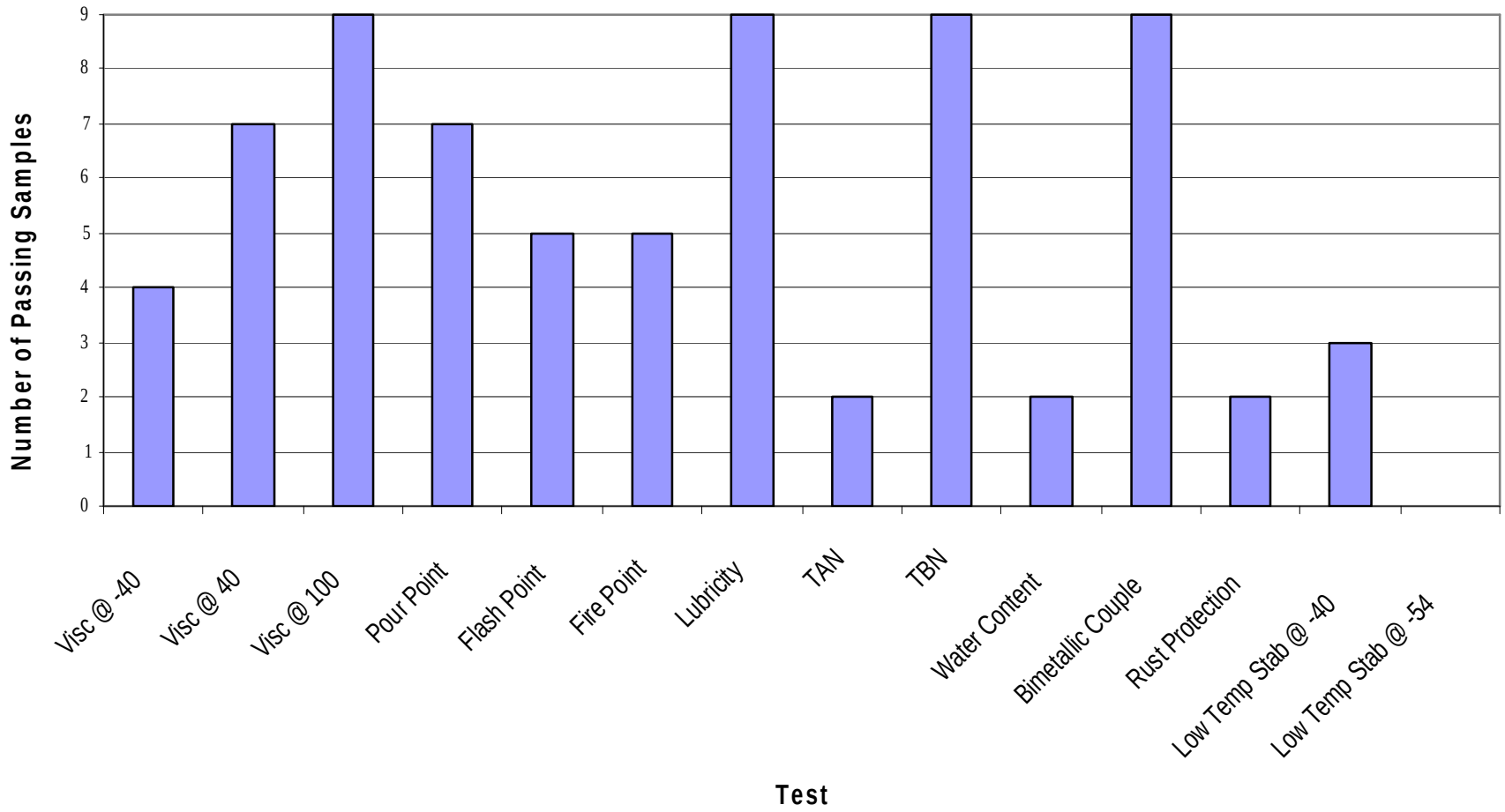
Max Spec limit for 46170 and 6083

Water Content



	A	B	C	D	E	F	G	H	I	J
FLTT	0.0611	0.1521	0.0116	0.0675	0.1148	0.0972	0.0447	0.0600	0.0737	0.0

Number of Passing Candidate Fluids for Each Test



Phase III

- Originally, candidate fluids were to be placed into selected tactical and combat vehicles of a selected organization for use during normal missions.

- However, since none of the candidate fluids could meet or exceed the specifications, Phase III has been postponed.

Interim Conclusions

- None of the candidate fluids have been down-selected to Phase III
- Low temperature properties and Total Acid Numbers are a problem for bio-based hydraulic fluids

QUESTIONS?