



Lubricant Contamination Study



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Objectives

- Determine the effect of chemical cleaning processes on the detectability of low cycle fatigue cracks in titanium, aluminum and nickel alloys
- Establish a quantifiable measure of cleanliness, including the minimum condition to allow effective inspection processing
- Update existing specifications to reflect the improved processes and provide best practices documents for use by the OEM's and airlines



Lubricant Contamination Study

- Three baseline runs
 - Removed 27 samples for use in developer chamber studies
 - Sorted samples into sets A – H attempting to have various brightness ranges represented in each set
 - Also considered standard deviation
- Step 1 – “Pristine samples” through each cleaning method
- Step 2a – If “pristine”, utilize sample set and cleaning method for lubrication study
- Step 2b – If significant reductions in brightness, attempt to return samples to pristine condition
- Step 3 – Apply lubricant and clean with steam/aqueous. Follow steam/aqueous with vapor degrease.
- Step 4 – Post baseline



Lubricant Contamination Study

Sample Set (A-H)	A	B	C	D	E	F	G	H	
Contaminant	None	LPS 1	2380 engine oil	Skydrol Monsanto 5	WD-40	Aeroschel 17	Molycoat 321	Dow Corning DC-33	DGF123
Cleaning Method	None	Steam with aqueous degreaser Turco 5948	Vapor degreaser	Aqueous degreasing and alkaline (CeeBee Super Bee 300LF)	Alkaline one step - long soak (Turco 4181L)	Alkaline derust (Turco 5948R) + long soak (Turco 4181L)	Alkaline three step - (Turco 4181L)	Four Step Alkaline Rust Remover, Acidic Scale Conditioner And Alkaline Permanganate Cleaning (Ni)	
	None	LPS 1	LPS 1	None	None	None	None	None	
		2380 engine oil	2380 engine oil						
		Skydrol Monsanto 5	Skydrol Monsanto 5						
		WD 40	WD 40						
		Aeroschel 17	Aeroschel 17						
		Molycoat 321	Molycoat 321						



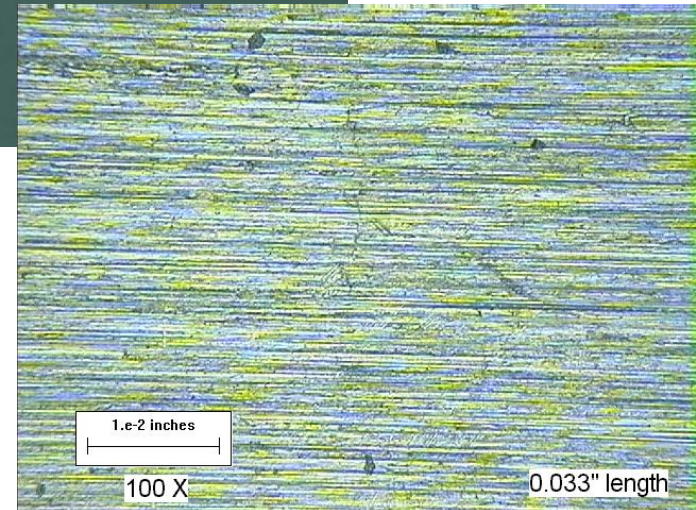
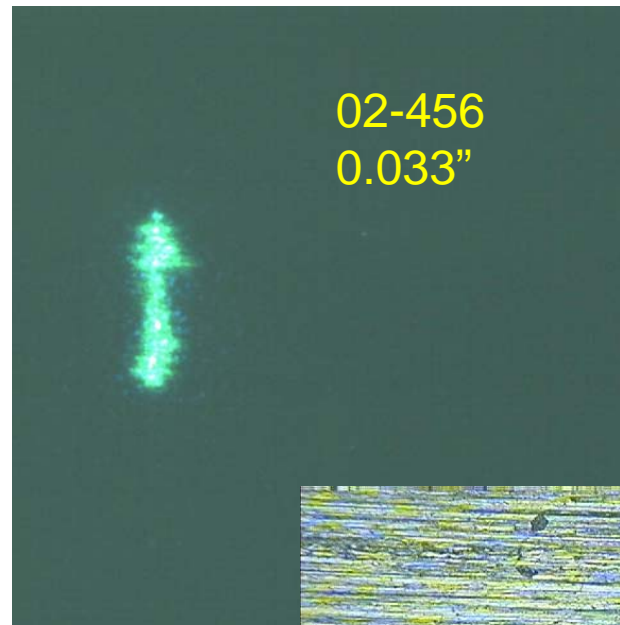
Sample ID Key

- 02 – 0xx samples are Ni
- 02 – 4xx samples are Ti
- 02 – 7xx samples are Al



Sample Characterization

- Final surface polish to 32 Ra
- Optical photographs (100X digital)
- Brightness measurements and UVA image capture to establish baseline and remove samples that showed variability



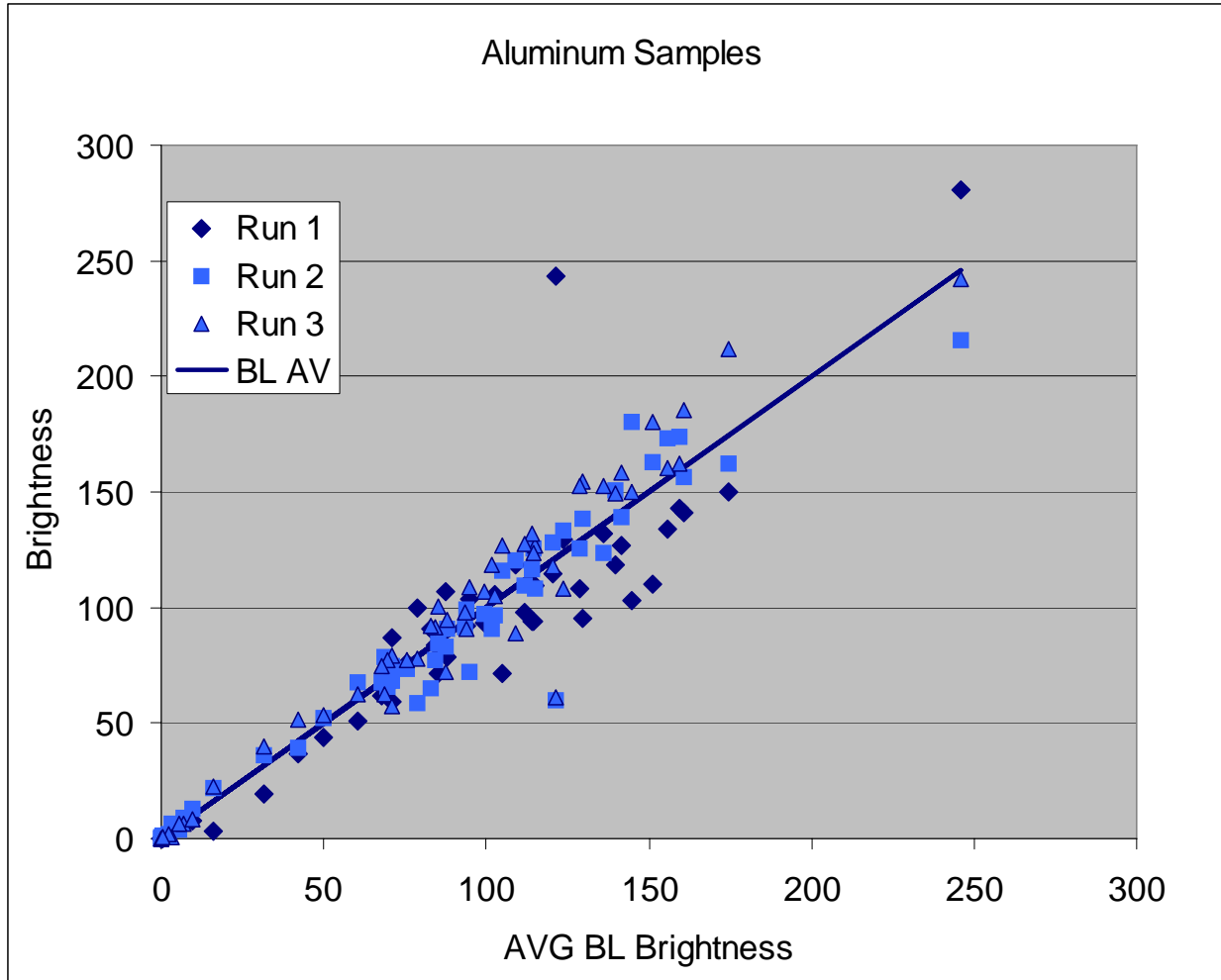


Field Studies

- Cleaning Study
 - Compare range of chemical methods for effective removal of contaminants without degradation to the FPI process

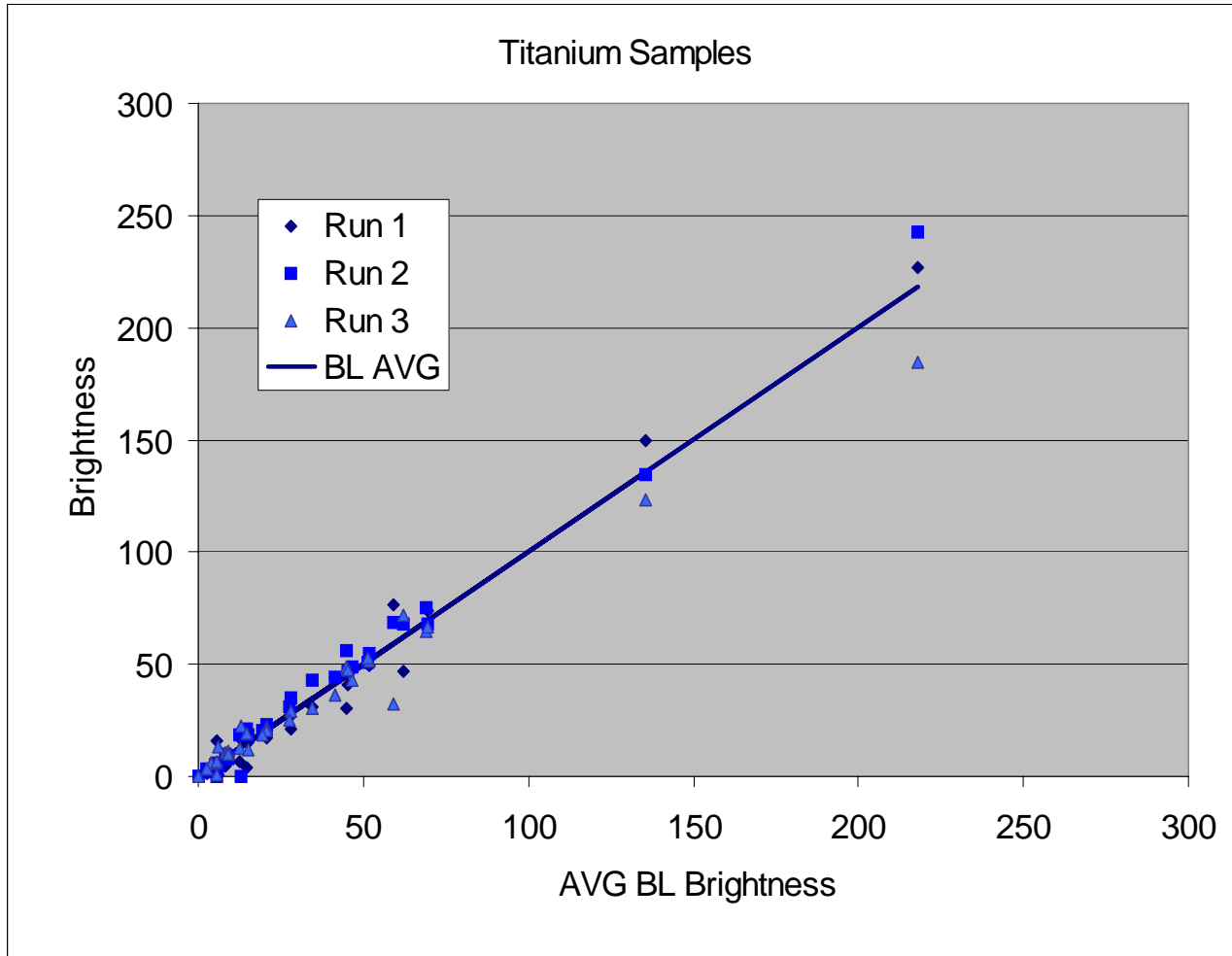


Baseline Data



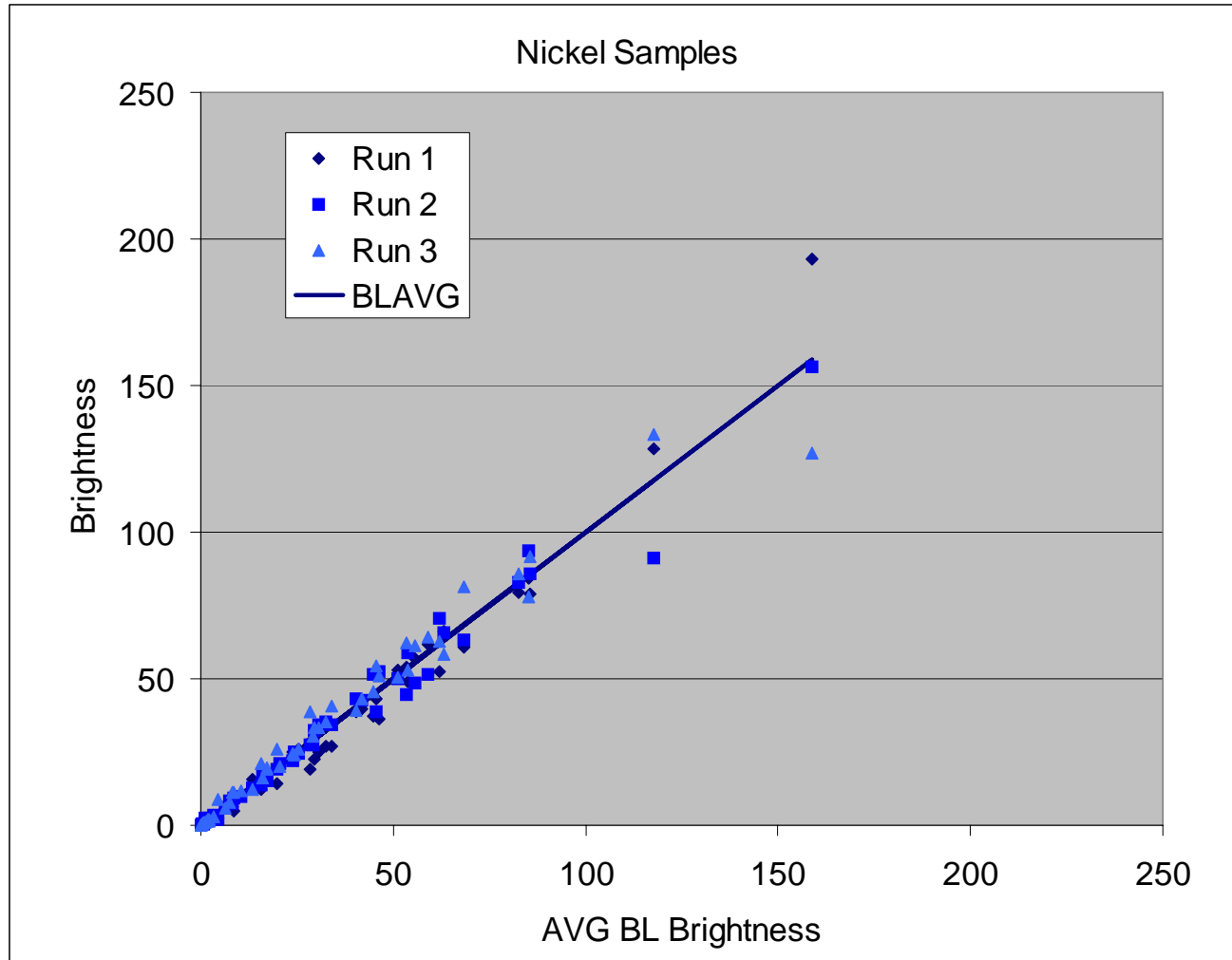


Baseline Data



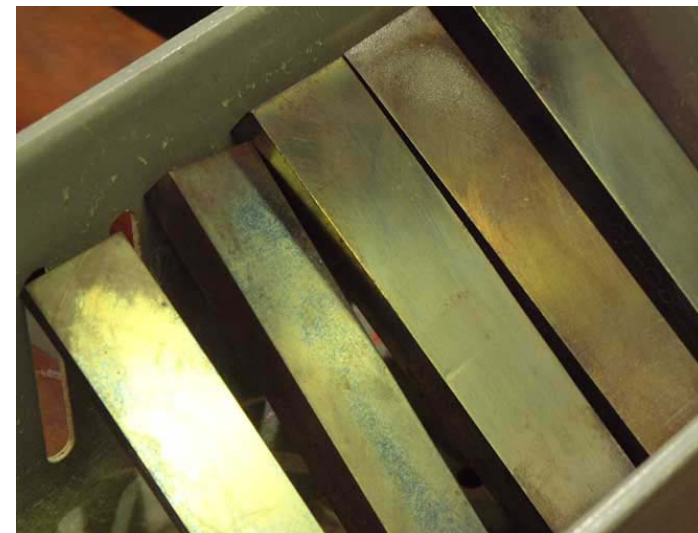


Baseline Data





Cleaning Study





Cleaning Study



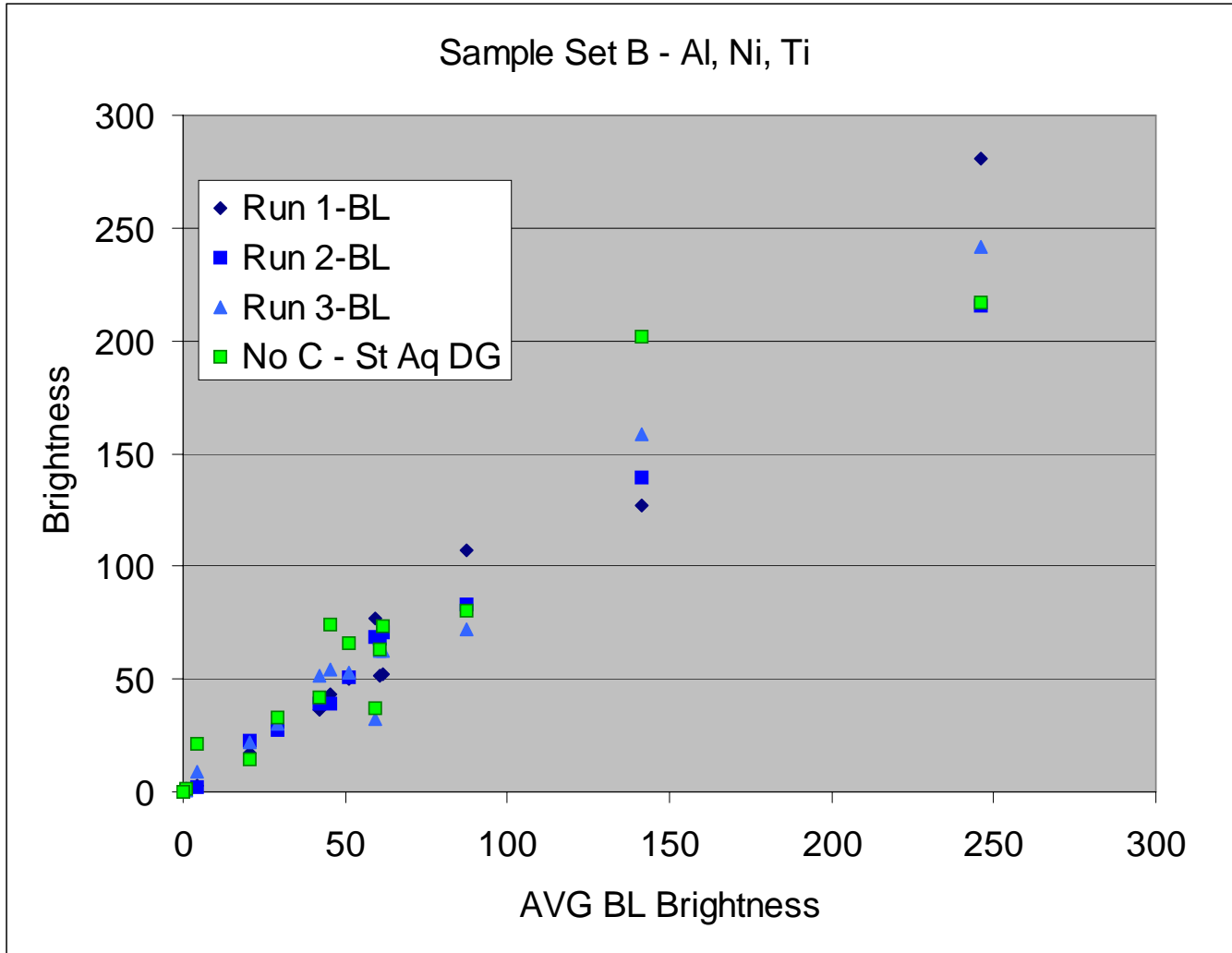


Chemical Cleaning Methods

- Aqueous degreasers and vapor degreasing were both effective for oil removal
- Neither technique was successful at soot removal

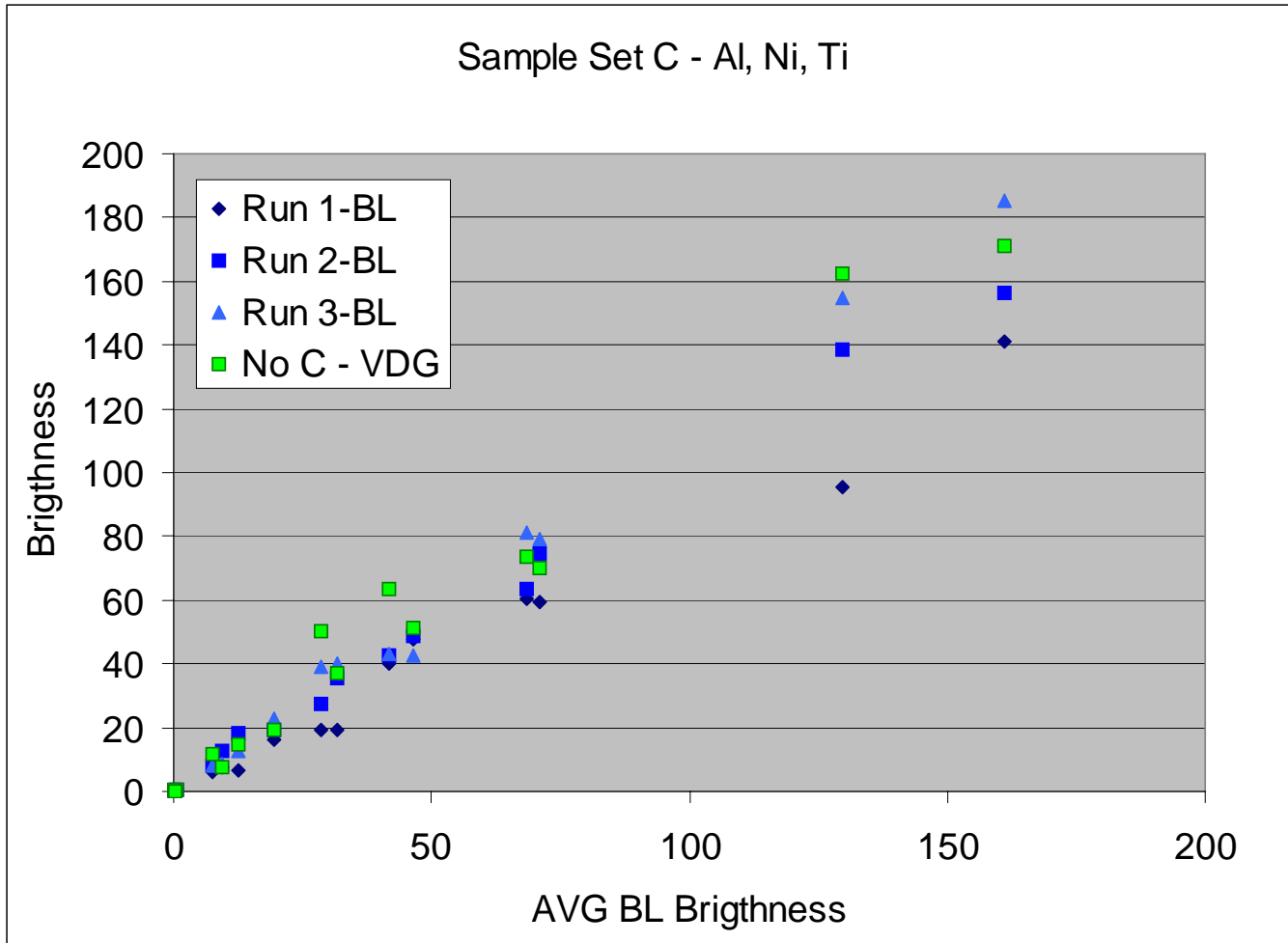


Steam + Aqueous Degrease



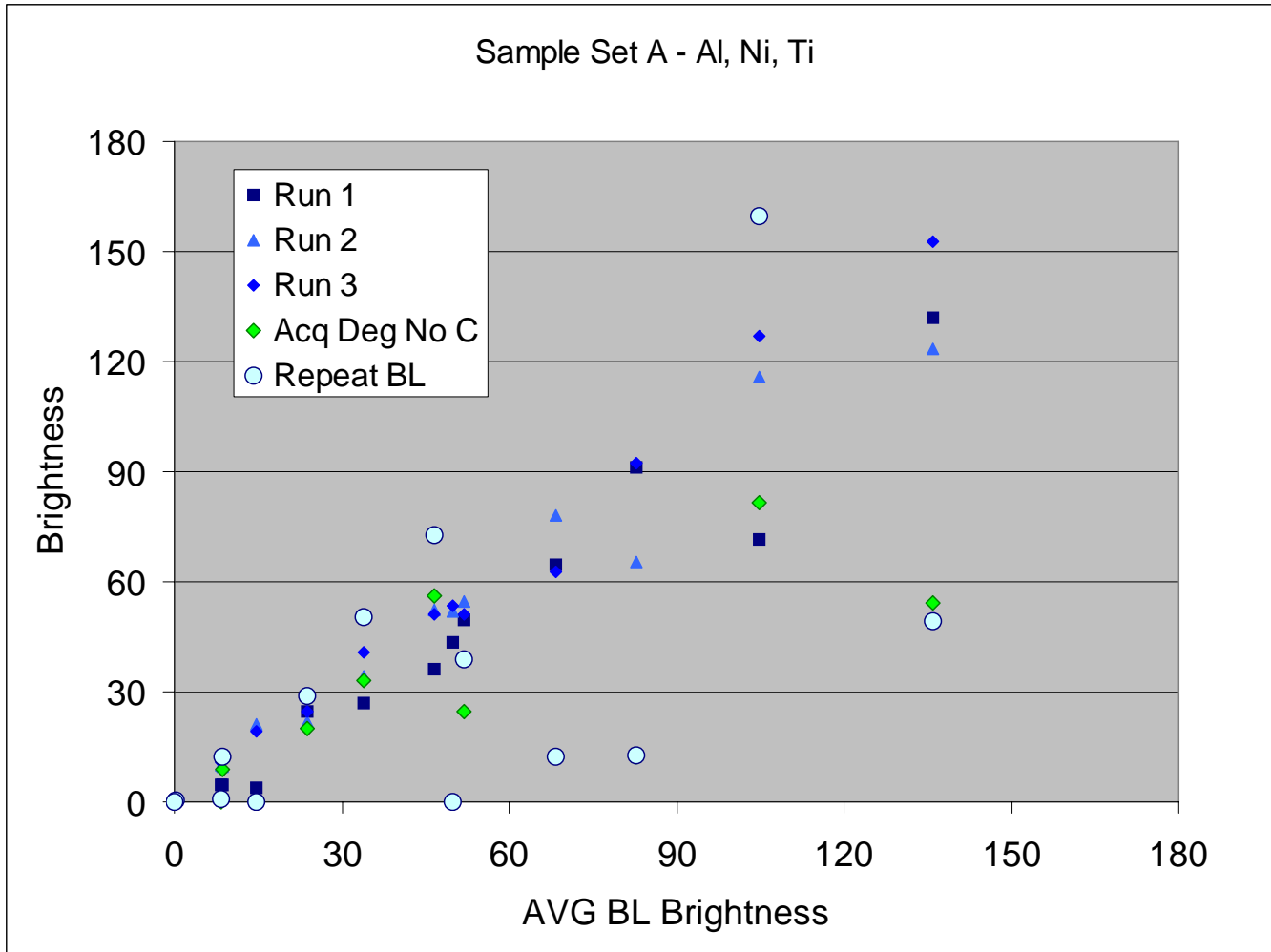


Vapor degreaser



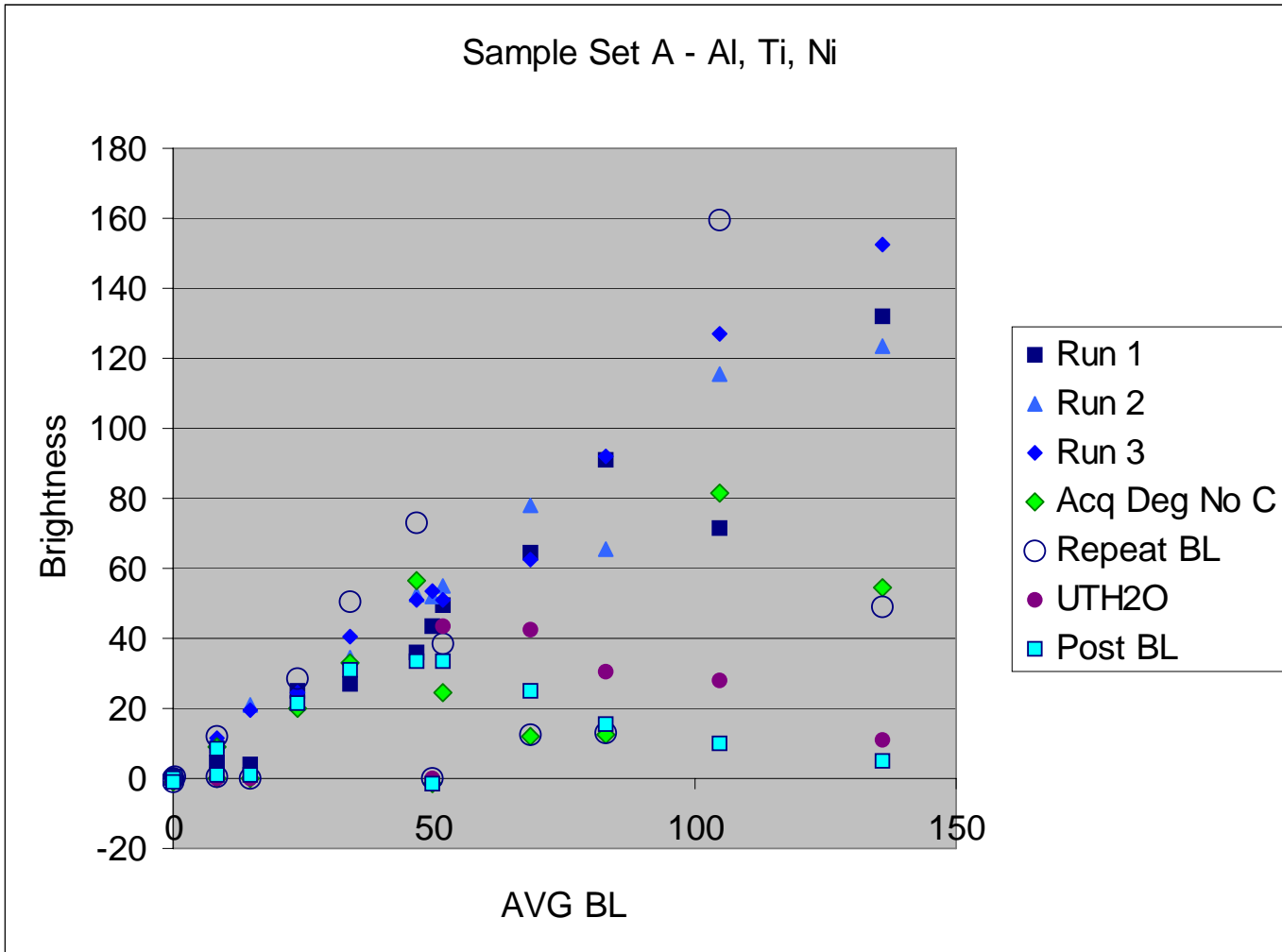


Aqueous Cleaner





Aqueous Cleaner



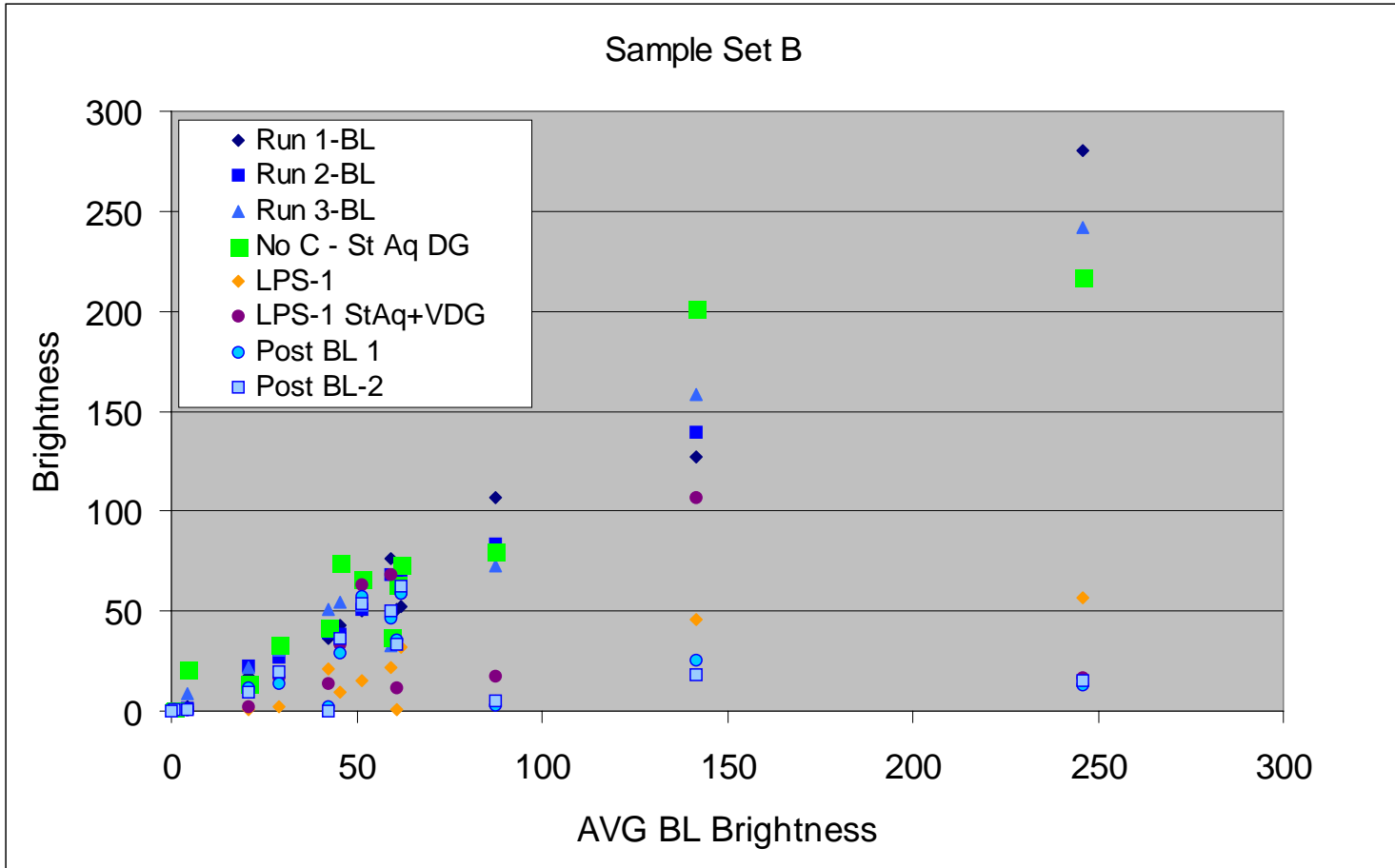


LPS - 1

- Samples heated to 160°F
- LPS-1 applied over sample surface including over crack
- Heated to 225°F for 2 hours
- Cooled and cleaned



LPS - 1



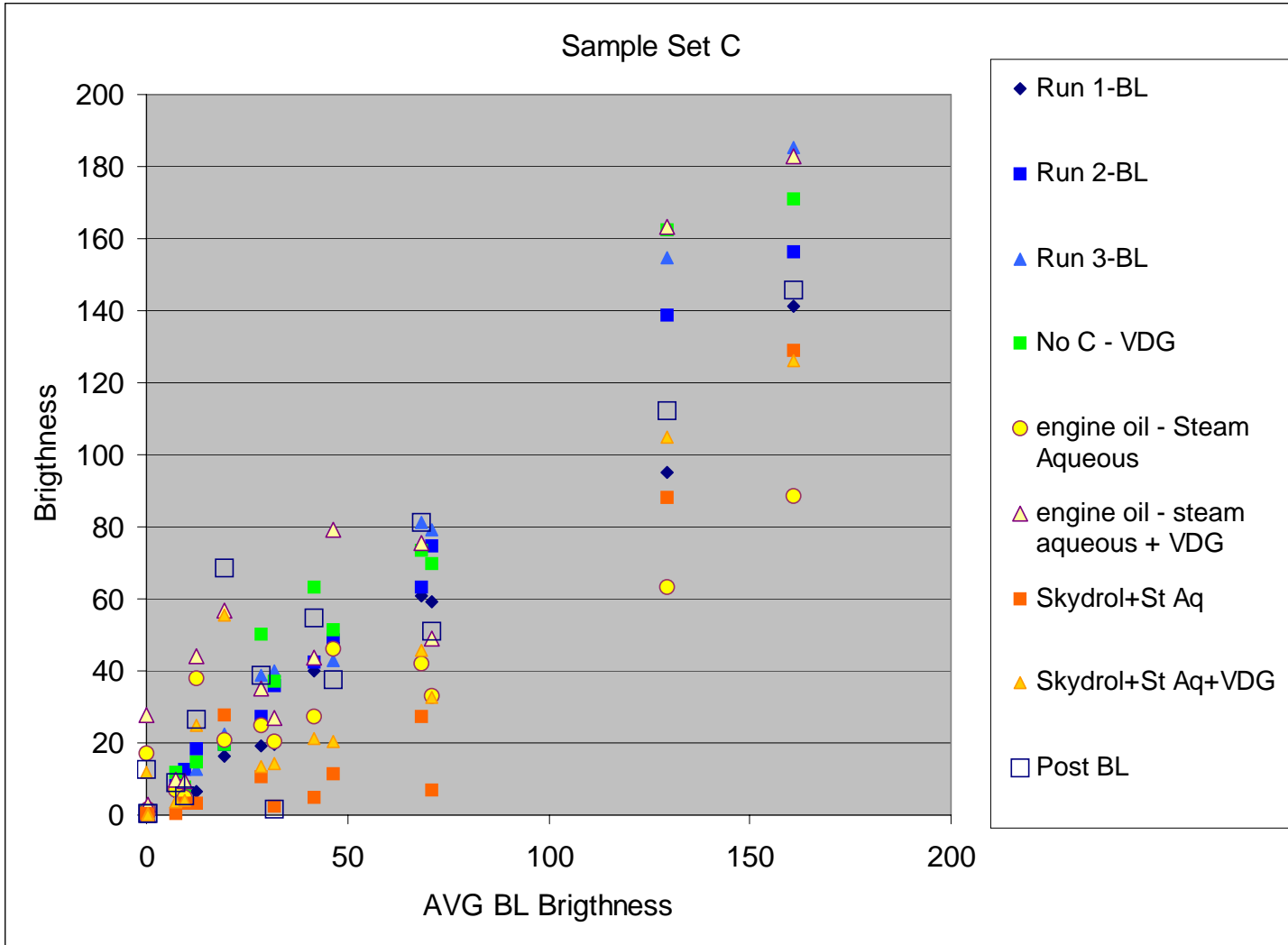


Engine Oil & Skydrol

- Samples heated to 160F
- Engine oil applied over sample surface including over crack
- Heated to 225F for 2 hours
- Cooled and cleaned
- Same samples used for Skydrol

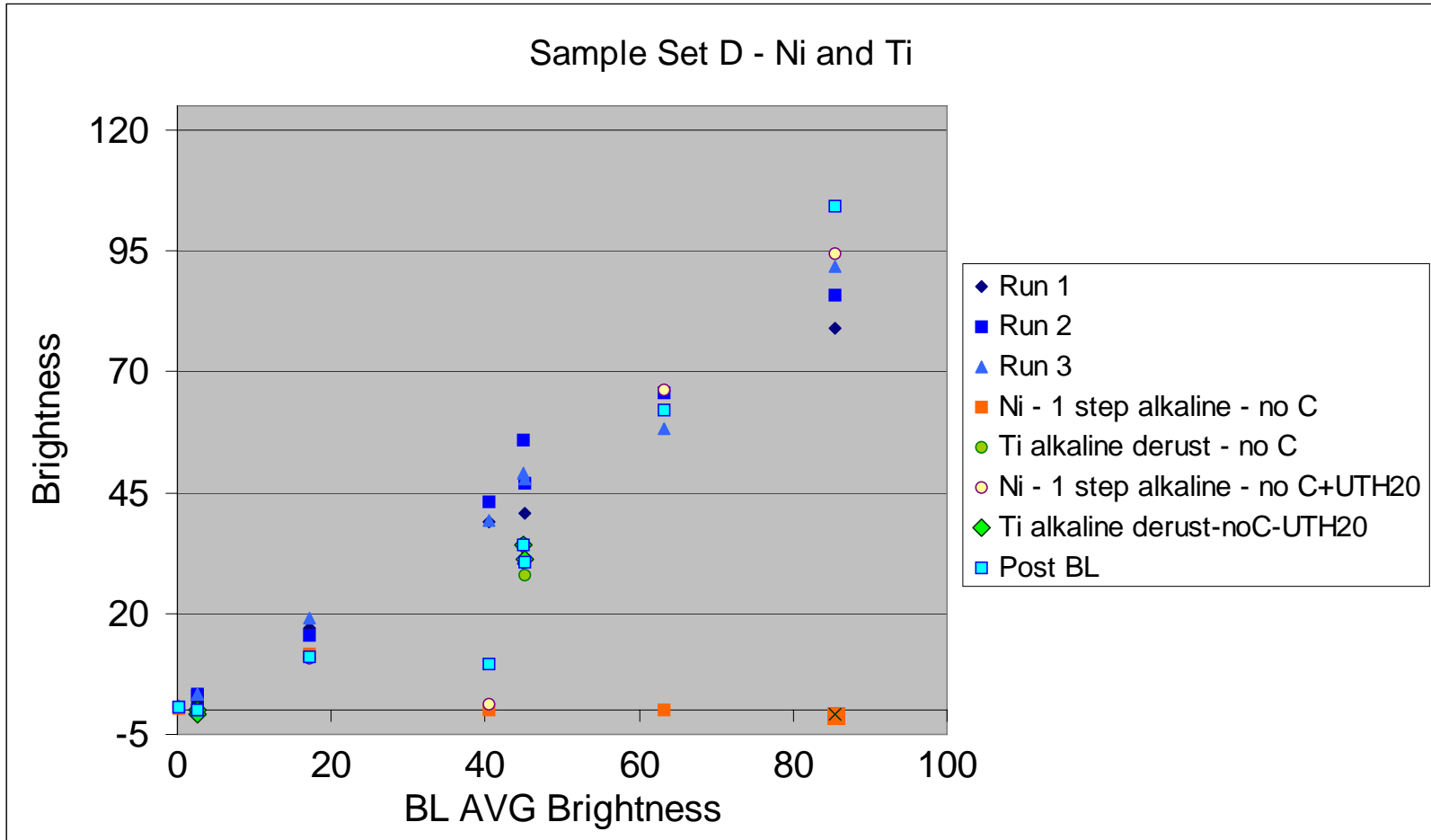


Sample Set C



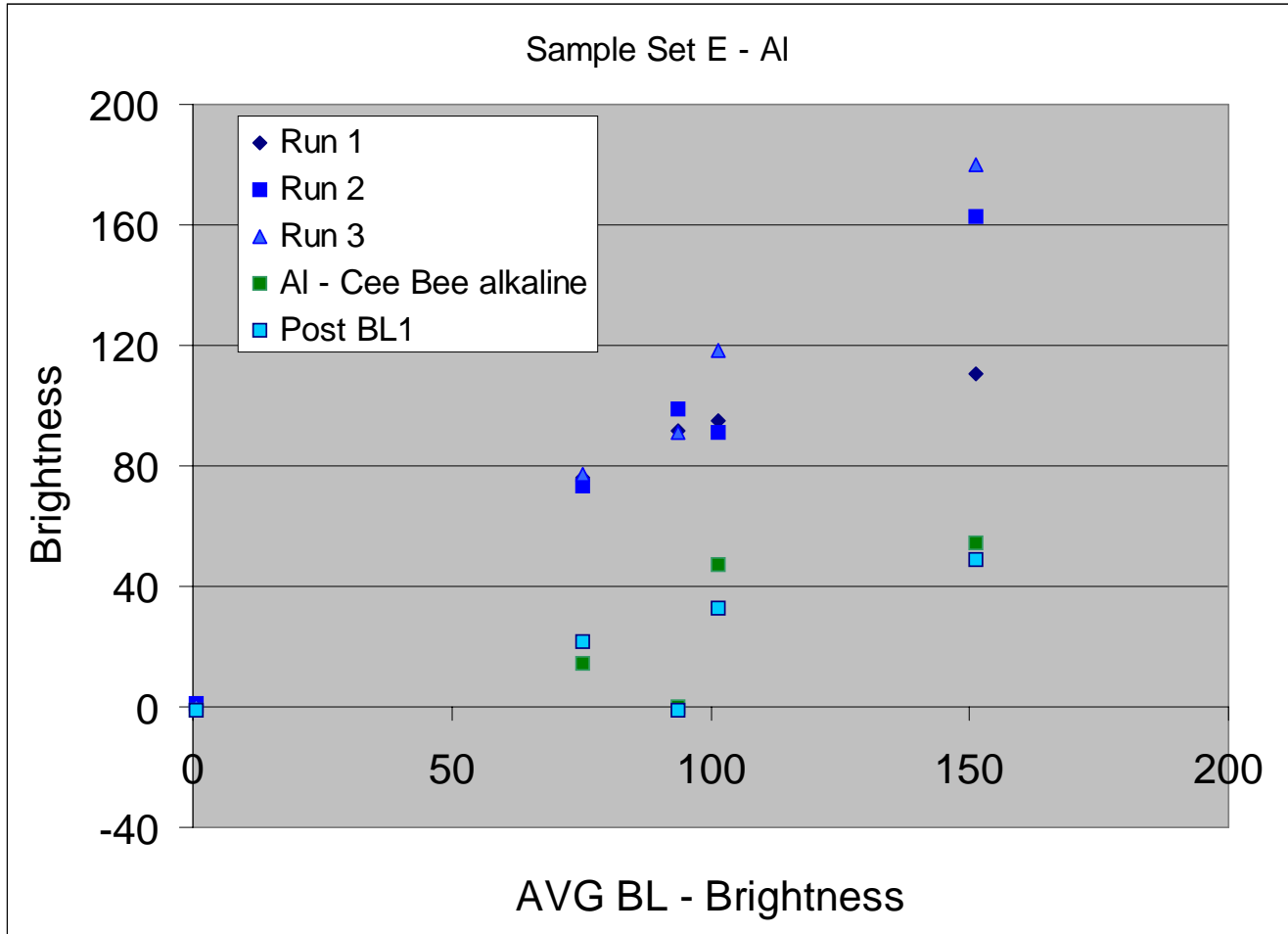


Sample Set D





Sample Set E





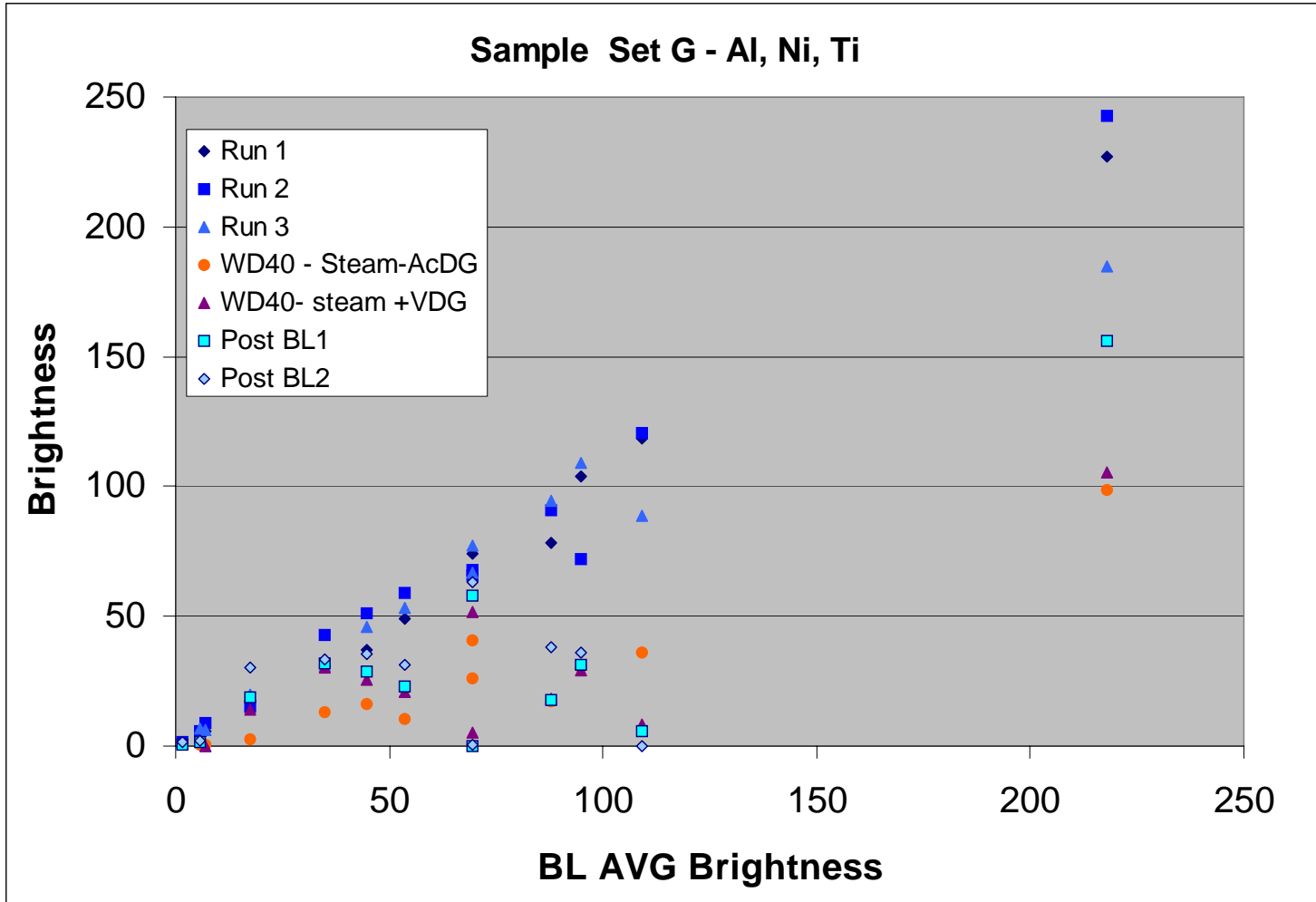
Grease

- Samples heated to 160F
- Aeroshell 7 grease applied over sample surface including over crack
- Heated to 225F for 2 hours
- Cooled and cleaned





Sample Set G – WD40





Conclusions

- Steam + aqueous cleaning method did not lead to reductions in brightness
- Vapor degreaser did not lead to reductions in brightness
- Some brightness recovery after UT distilled water
- Steam + Aqueous was not effective for cleaning penetrating oil
- StAq followed with VDG lead to some improvements
- Alkaline cleaner had strong effect on brightness for Ni and Ti
- Able to recover all but one Ni sample with UT distilled water



Conclusions

Alkaline cleaner had significant effect on AI samples

Unable to recover on-site

Micrograph and cleaning steps underway

Steam + aqueous cleaner not sufficient to remove grease from all samples

VDG showed improvement in most samples

Samples did return to baseline conditions with further acetone cleaning

Steam + aqueous cleaner not sufficient to remove WD40 from samples

VDG showed improvement in most samples but did not return samples to baseline

Micrographs and cleaning steps underway at ISU