



# Radiographic Image Quality Enhancement

## by the Use of Copper Filters

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### Introduction

Step wedges of different materials were used to compare radiographic density with and without a copper filter to identify the effects of the copper filter at different energies and exposure times.

### Set-Up

- X-ray sensitive 14" x 17" radiography plates were used in cassettes with or without an internal copper filter.

-Plates were exposed in a Faxitron cabinet X-ray device under the following parameters:

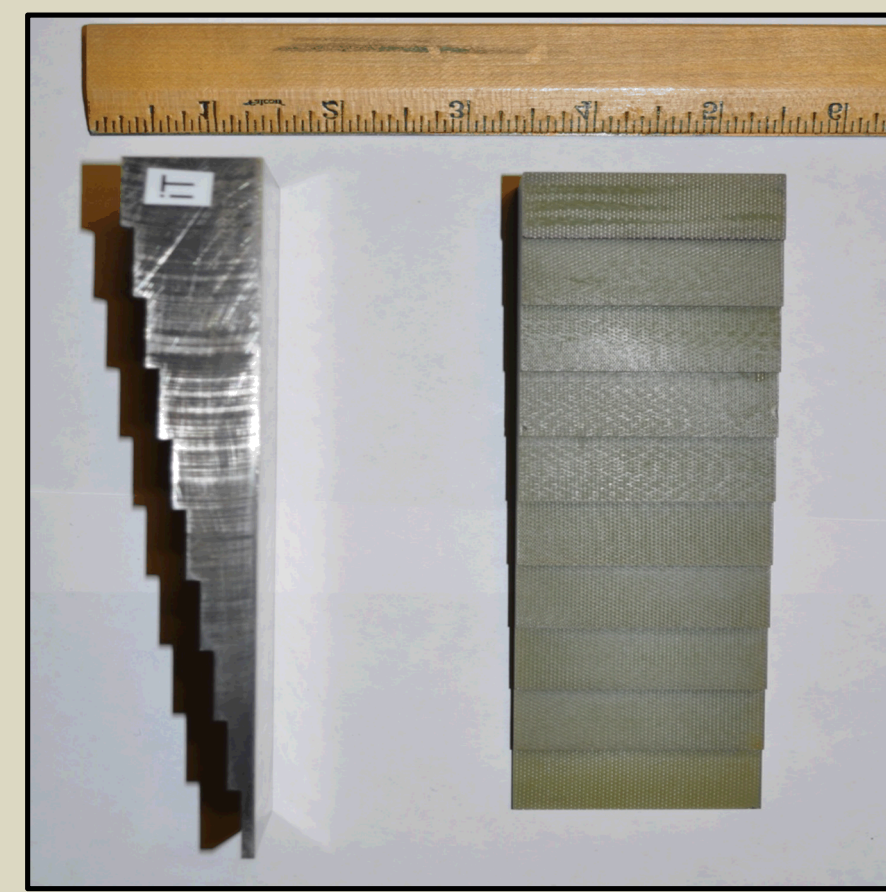
Voltage = 70kV and 130kV

Current = 3mA

Time: 15min. and 5min.

Dose = current x time, e.g. 3mA x 15min. = 45mAm

-Plates were read with a Kodak Industrex HPX-1 scanner at a resolution of 35 microns.



Left- Step-wedge have steps at 0.1 in intervals  
Right- Step-wedges as exposed on cassette

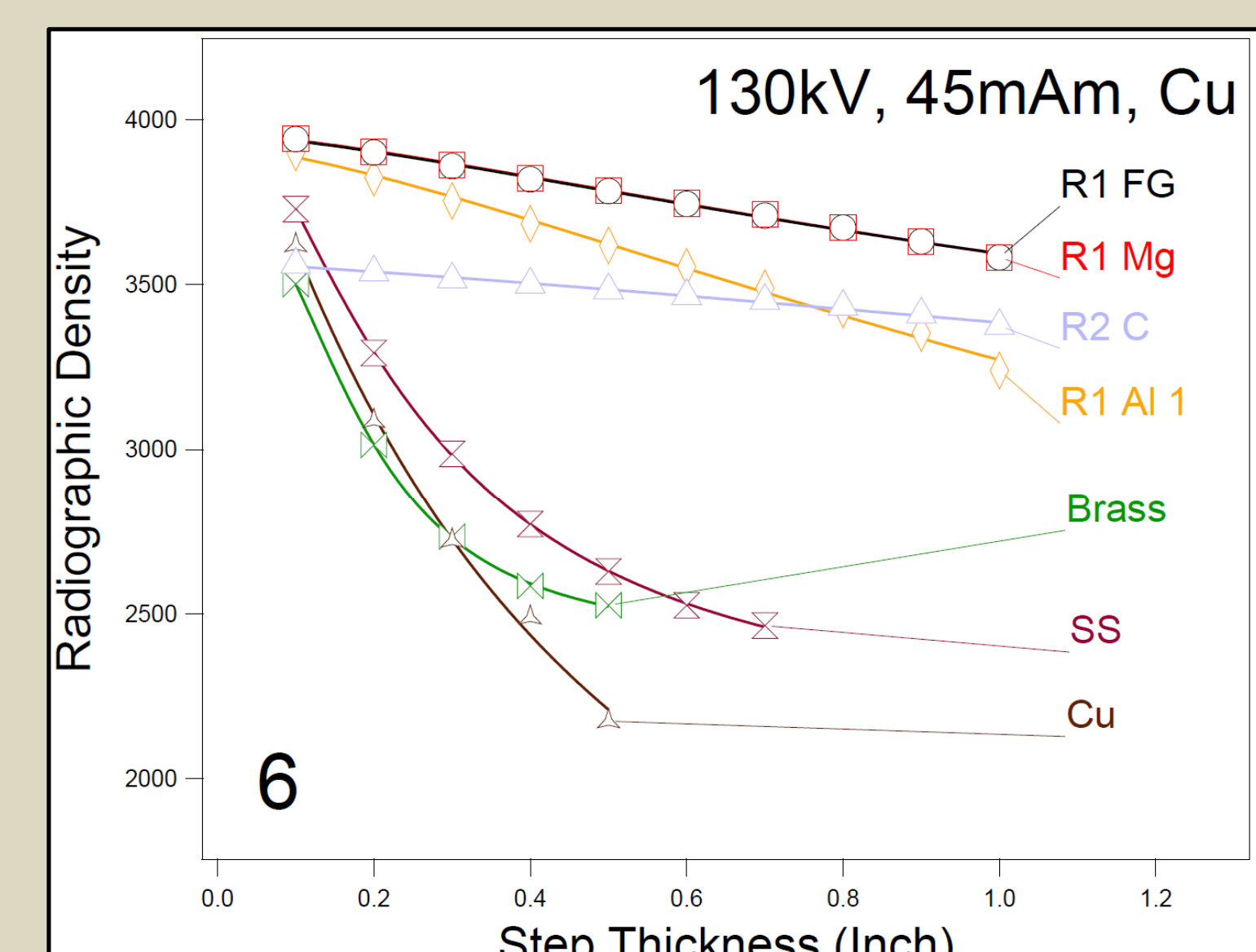
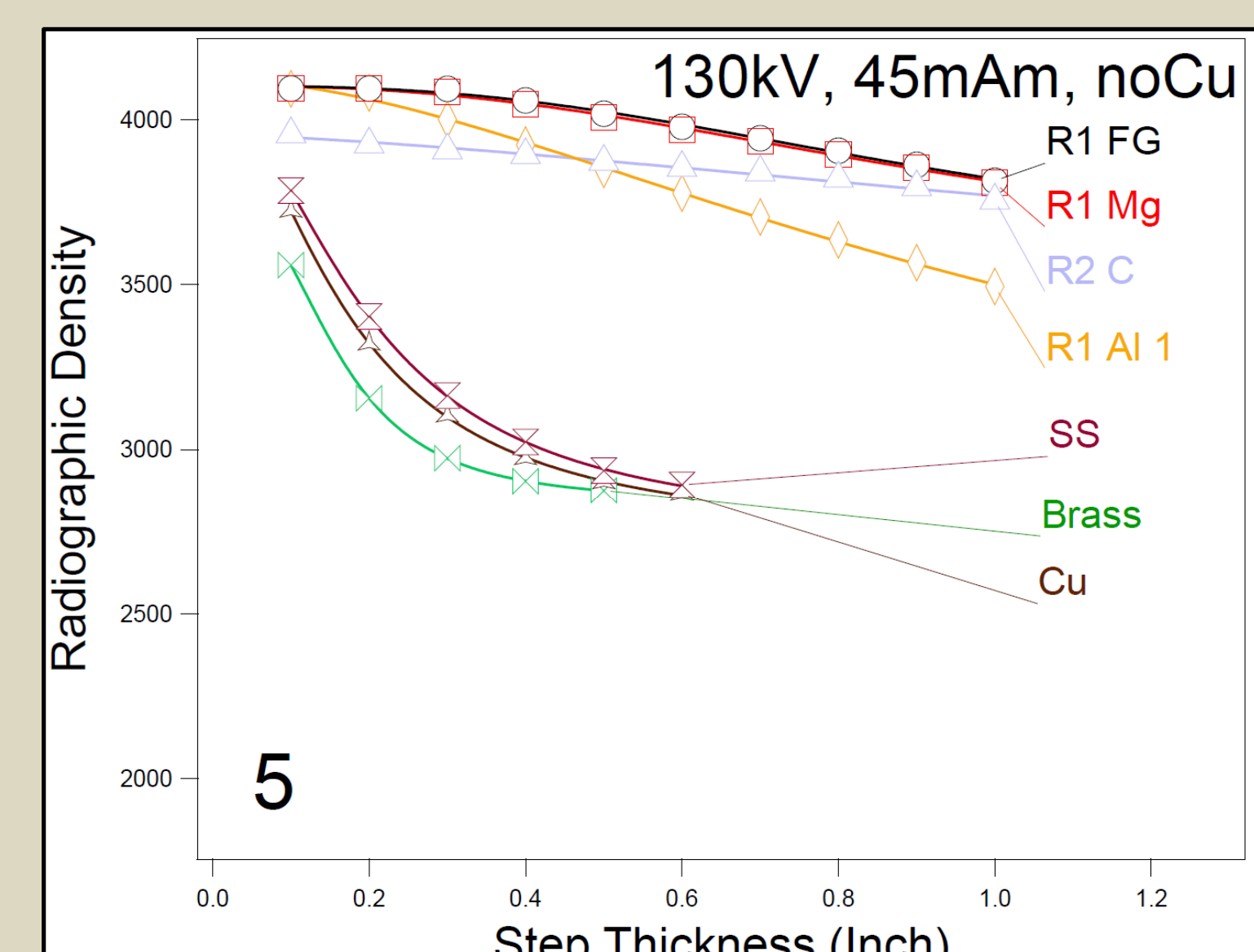
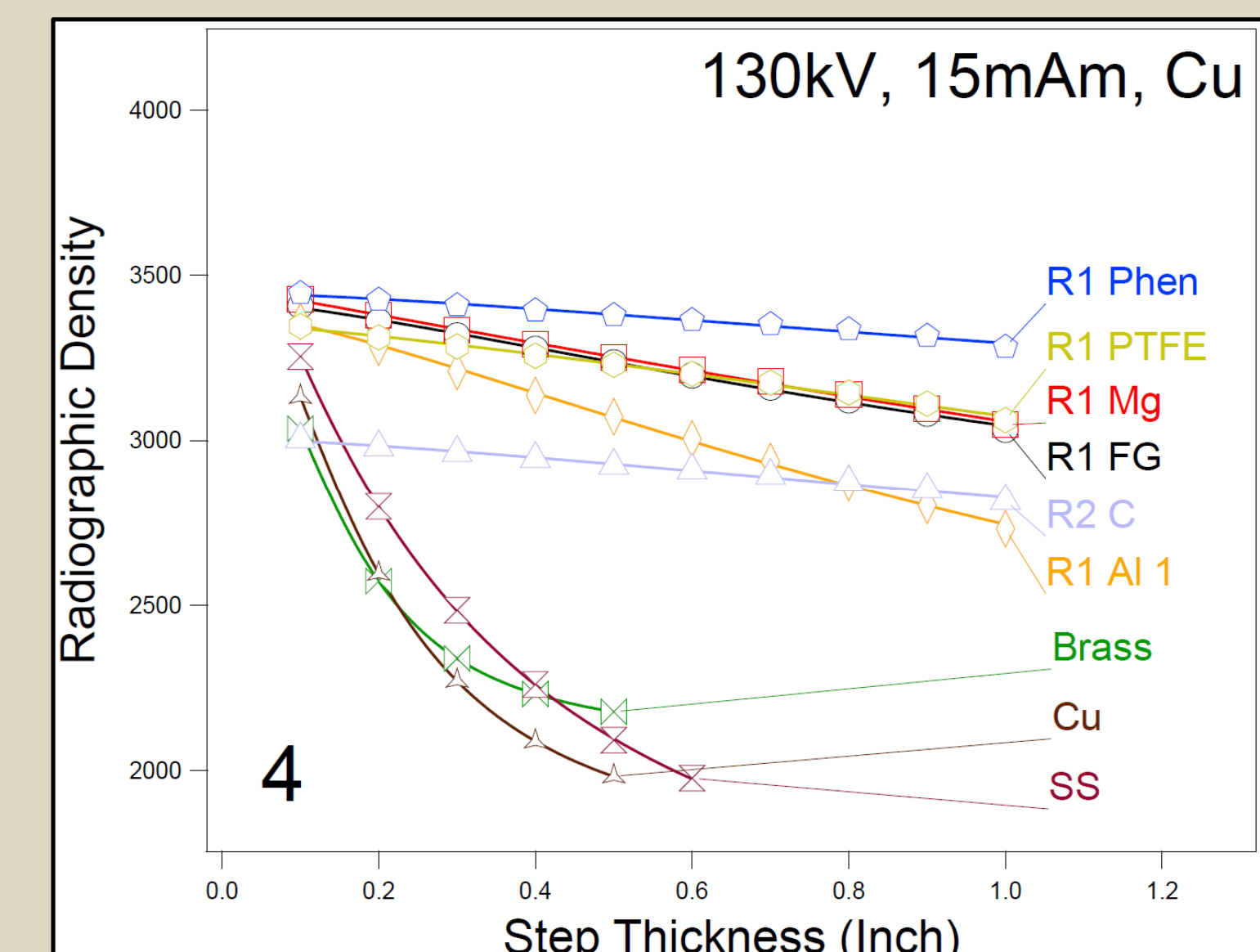
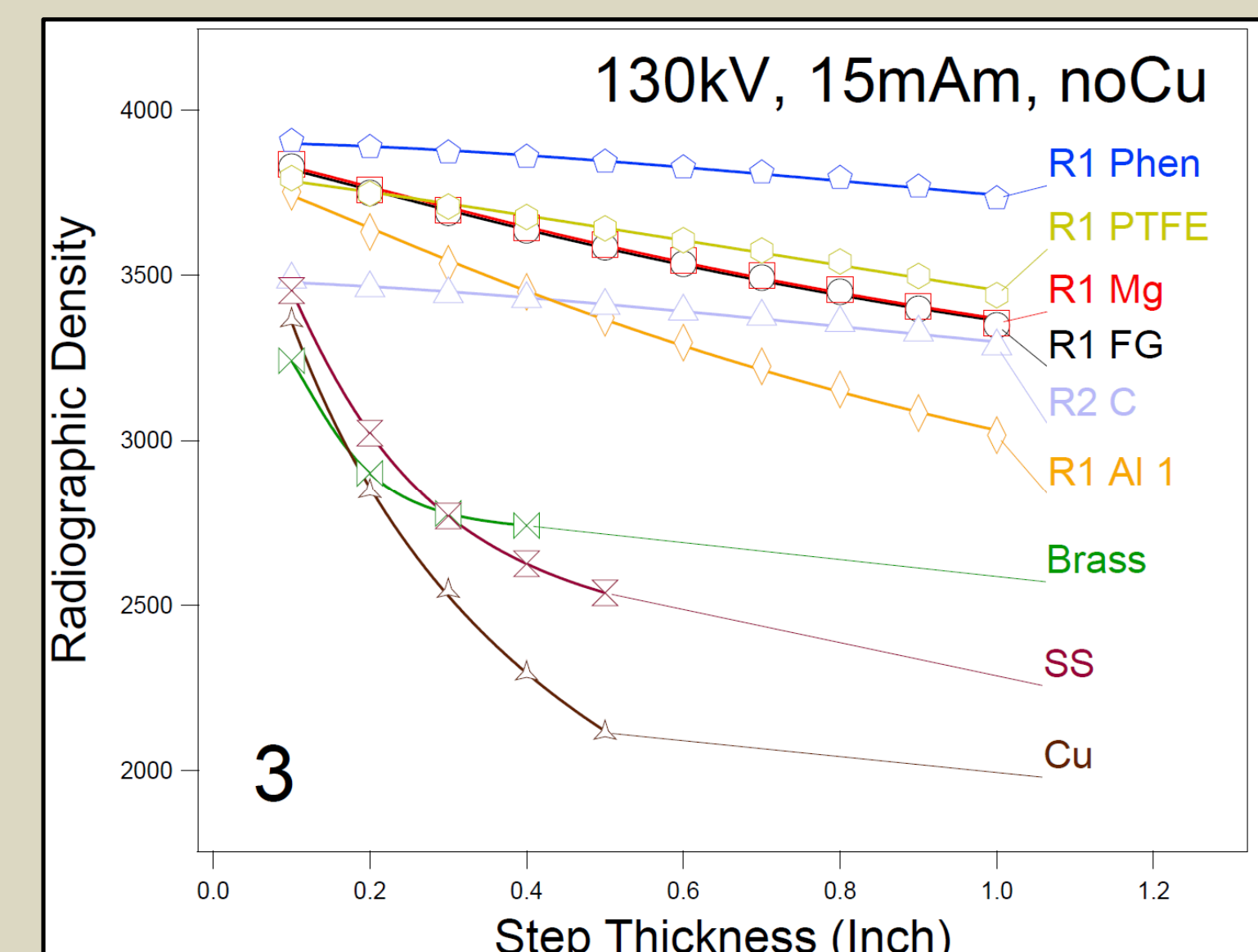
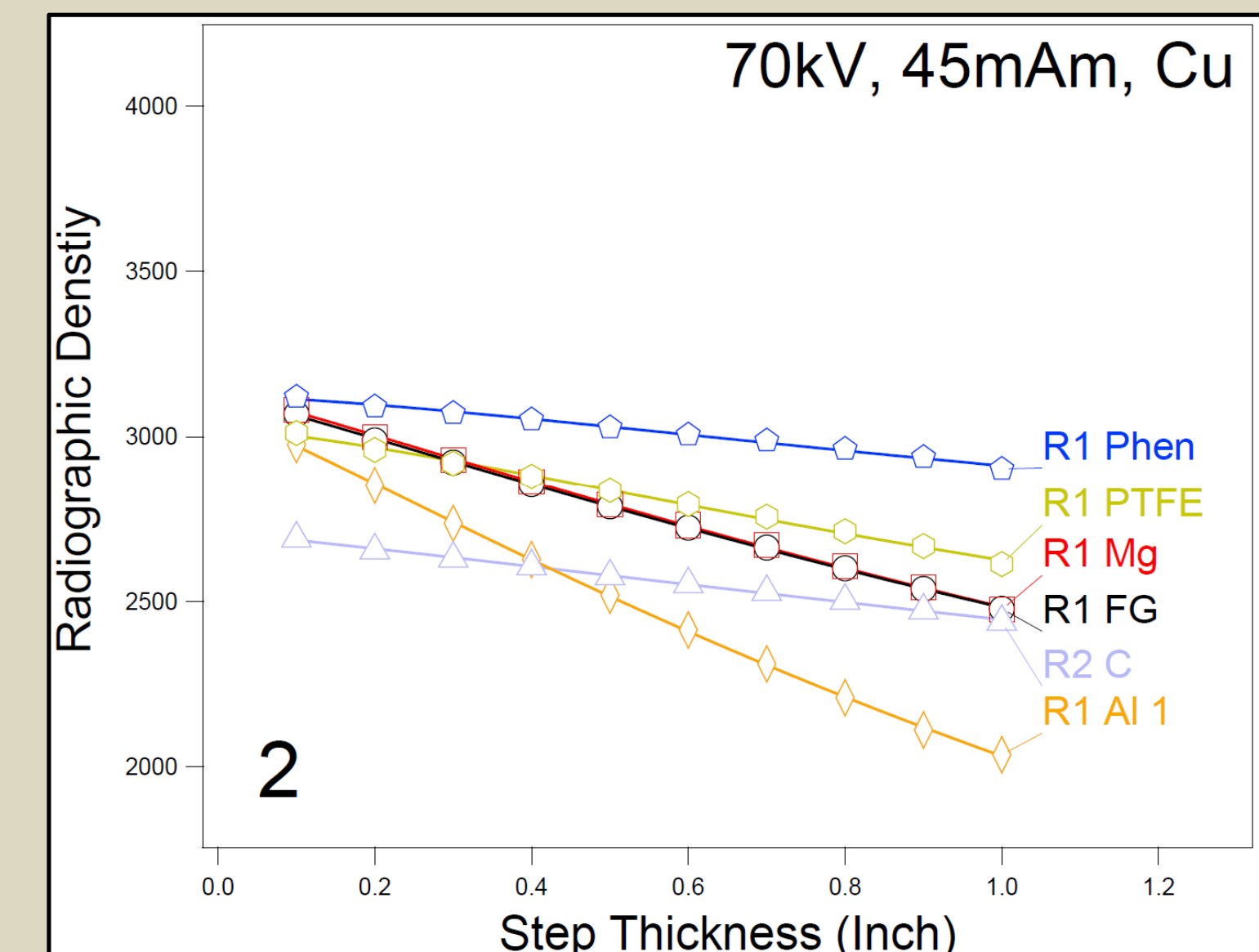
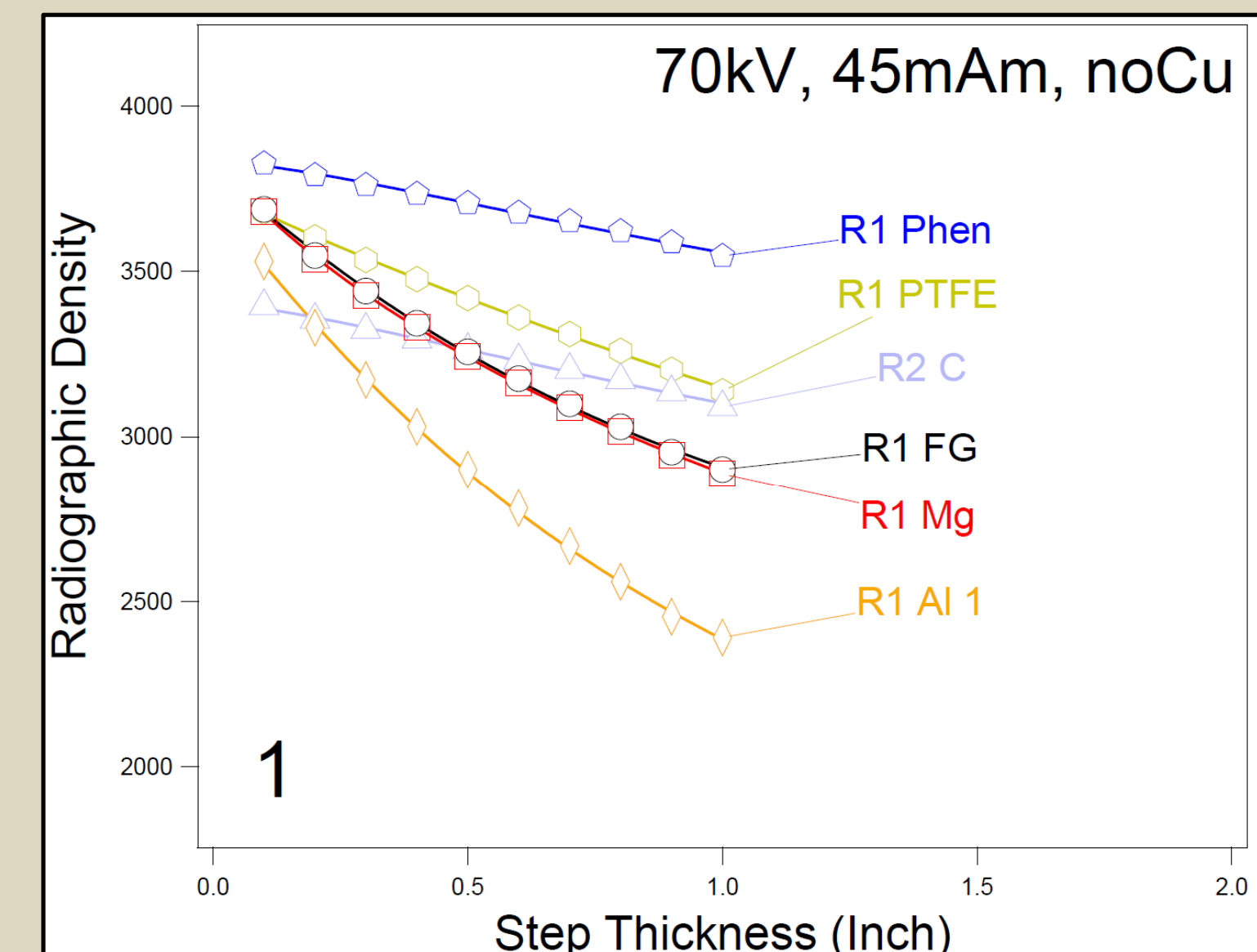
### Material Information

	Abbrev.	Density (g/cc)
Phenolic	Phen	~1.51
Magnesium	Mg	1.74
Epoxy Fiberglass	FG	1.8
Teflon	PTFE	2.2
Carbon	C	2.267
Aluminum 1100*	Al1	2.61
Stainless Steel 304L**	SS	8.03
Brass***	Brass	~8.57
Copper	Cu	8.96

\*99% Al, <1% Cu/Mn/Zn/Si/Fe  
\*\*69% Fe, 19% Cr, 10% Ni, 2% Mn  
\*\*\*Typical Brass ~60% Cu, ~40% Zn



Example of a radiographic image with step wedges.



The graphs represent the data obtained from individual radiographs at the labeled conditions. During the scanning process, 60% of the plate's radiographic signal is used in order to produce the radiographic image. If some of the step images are too dense to show the boundary between steps, the plate can be rescanned to give a less saturated image, bringing the lower density into a range where differences in step thickness are observable.

R1 represents rescan #1, and R2 represents rescan #2. If no R1/R2 is present before a curve label, the line represents the original scan. An ideal radiographic image for step differentiation would be a curve with a density in the 3500-2500 range. For measuring small thickness variations a steep slope in that range is ideal.

For the 70kV tests, materials of densities > 8g/cc produced indistinguishable radiographs. CRS (cold rolled steel 1018) and Al 6 (Aluminum 6061 T6) were taken out of graphs for clarity since their curves are similar to 304L SS and Al 1100 respectively.

### Summary

-Some curves displayed a polynomial shape while others exhibited a more linear shape.

-Materials with densities >8g/cc give polynomial shaped curves.

-Materials with densities < 3g/cc give linear curves.

-The copper filter consistently lowers the density numbers of all materials under every condition.

-Epoxy Fiberglass (FG) and Mg have similar densities despite being of a different composition yet:

-Their curves are always similar, if not overlapping.

-This suggests that the curve shape of a given material reflects material density, not necessarily composition.

### Conclusions

The advantages of copper filter are:

Cu lowers the radiographic density of materials with densities <3g/cc, shifting them into the desirable 3500-2500 range. (Graphs 1-4)

Cu increases the slope of the curve for materials of densities >8g/cc. This allows small differences in thickness to be distinguished. (Graphs 5-6)

### Future Work

Use a higher voltage to differentiate the steps for tantalum and tungsten (density > 16g/cc) and for the thicker steps of the materials with density >8g/cc. These materials and step heights showed no discernable steps in the current work.

Place the copper filter above the samples rather than in the cassette to see if this has the same effect. This would be a less expensive method of achieving the same end at the risk of not noticing the filter has been left in place.

Titanium (not shown) displays a non-monotonic density vs. thickness curve. Further experimentation needed to understand this effect.