Application of Master Curve Fracture Toughness for Reactor Pressure Vessel Integrity Evaluation of BVPS-1

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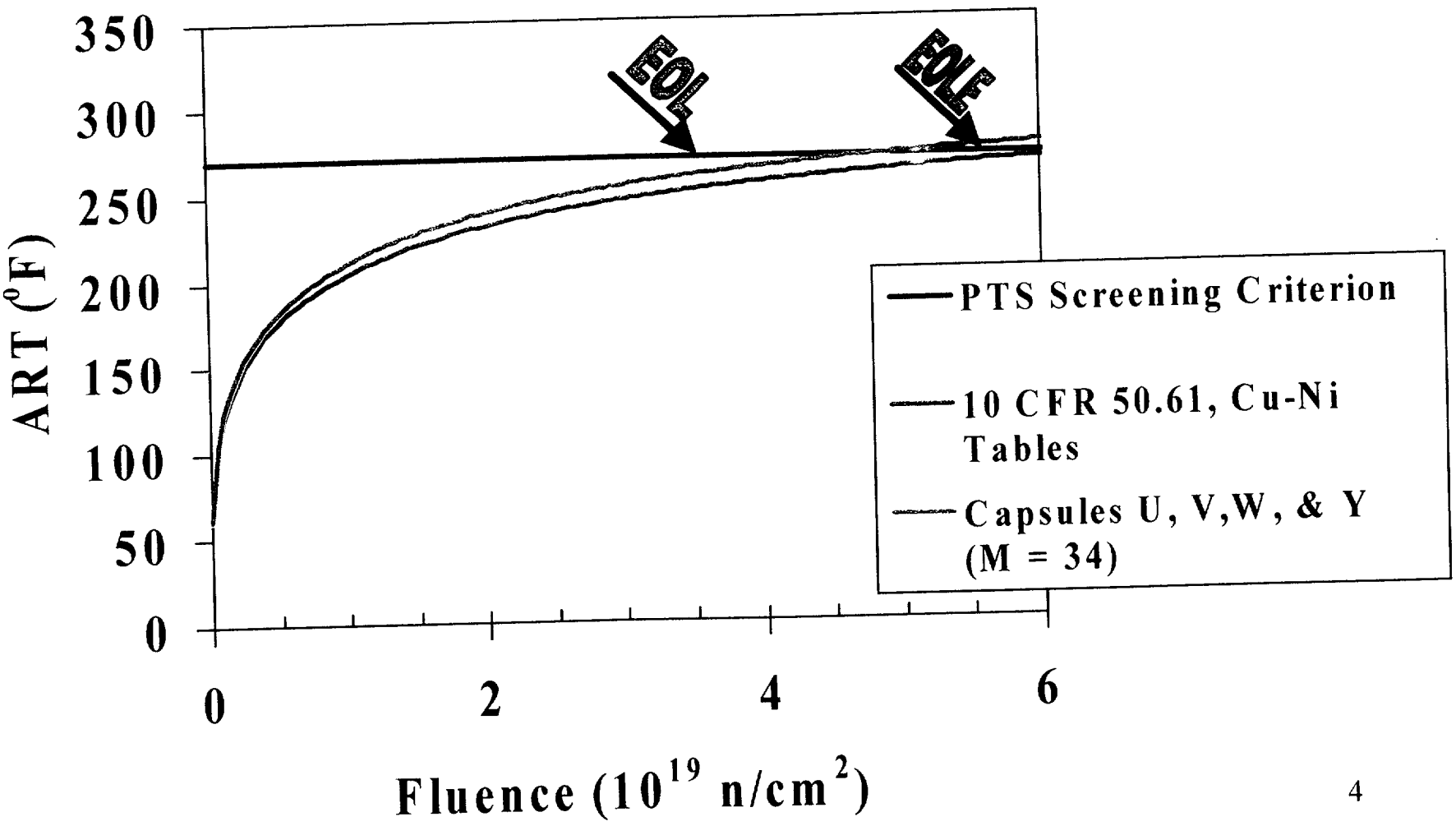
Beaver Valley Master Curve Application

- Purpose
  - Discuss the Submittal Approach
  - Discuss Unirradiated Material Property Relevance to ART
  - Discuss Uncertainty in ART at EOLE
  - Discuss Margin Application

Goals

- Provide confidence of the Material Properties for all Beaver Valley Reactor Vessel Materials
- Provide Operational Flexibility in Current License Life
- Provide confidence to both NRC and FENOC Management that PTS is not an EOLE concern
- Provide improved understanding of the irradiation effects on Beaver Valley Reactor Vessel Materials

Why Are We Here?



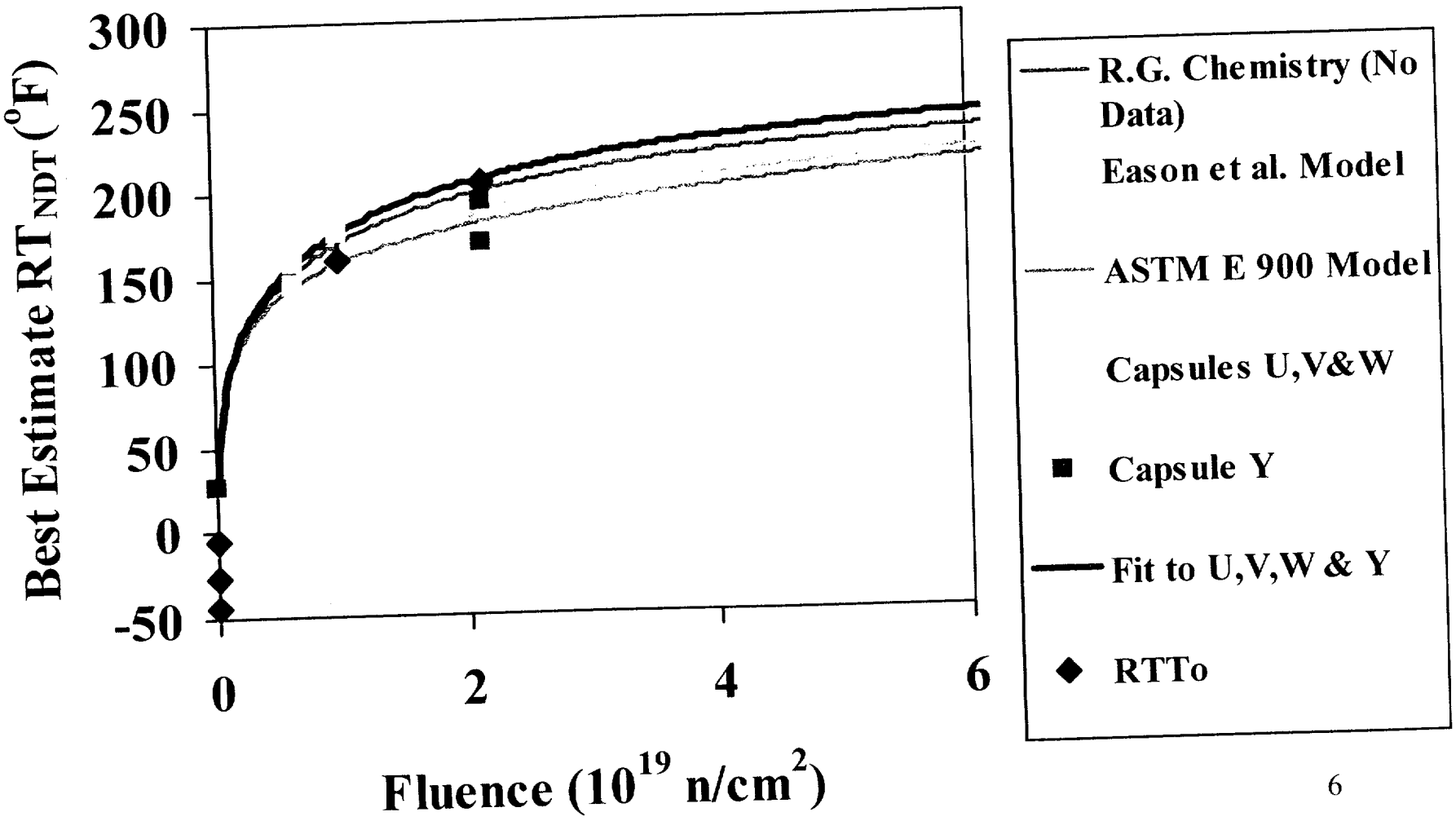
FENOC Response

- It is clear that the BVPS-1 plate is a radiation-sensitive material
  - ✓ The EOLE projections for RT_{PTS} approach the PTS screening limit
- In this situation the technically responsible approach is to apply the best available technology:

  Master Curve!

In order to understand this approach, we need to go back and look at how the various ***best estimates*** (which include Charpy bias) of the Reference Temperature were constructed.....

How Did We Get Here?



Two Options for Analysis of Master Curve Based RT_{To}

Shift-Based Approach

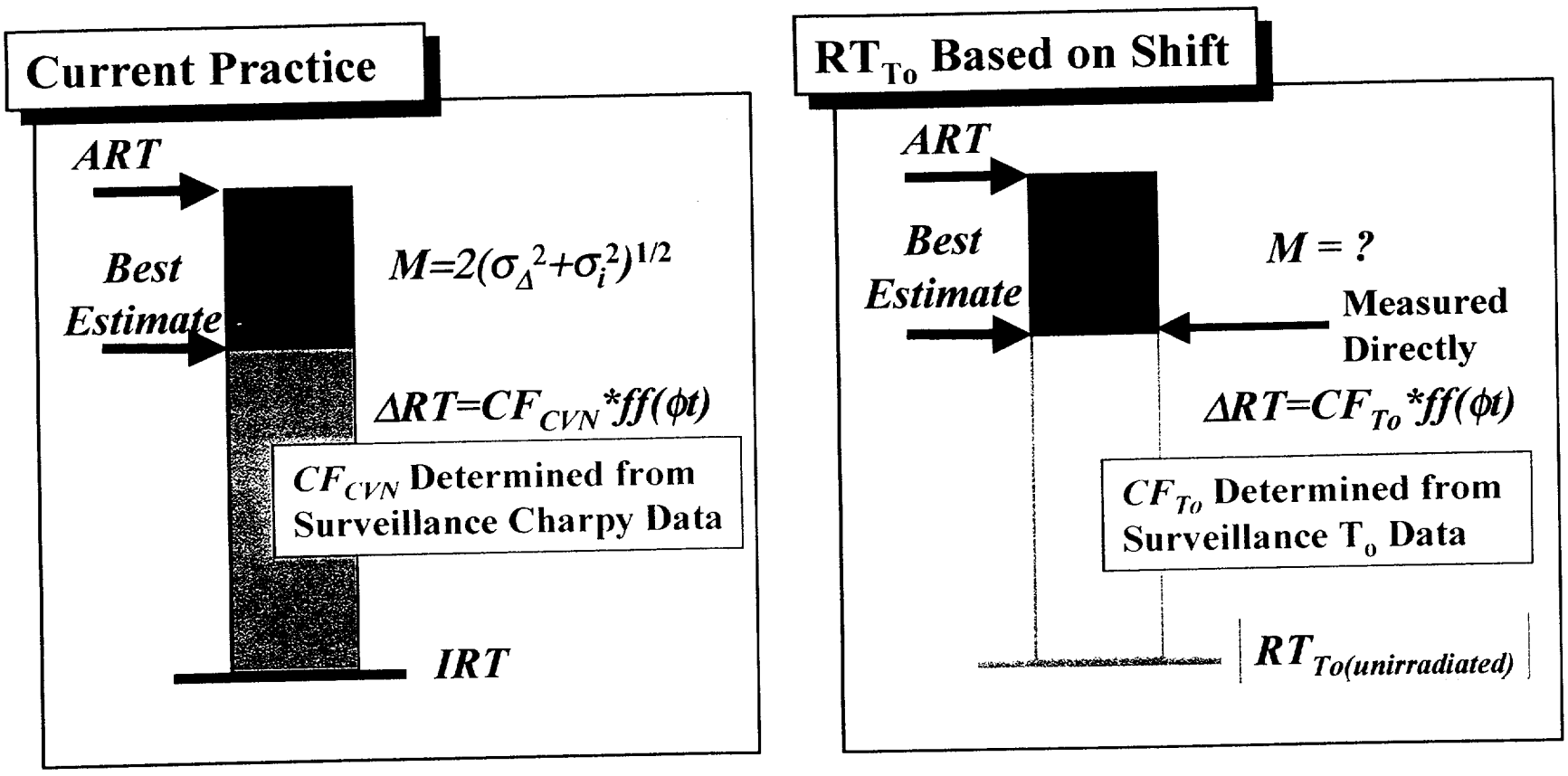
- ✓ Parallel to Charpy approach
- ✓ Method applied in Kewaunee & FENOC Submittals
- ✓ Does not take advantage of ability to test irradiated material
  - **Excessive Margins Can Result!**

Direct Measurement

- ✓ Takes advantage of testing irradiated material
- ✓ Basis for proposed Margins in FENOC Submittal

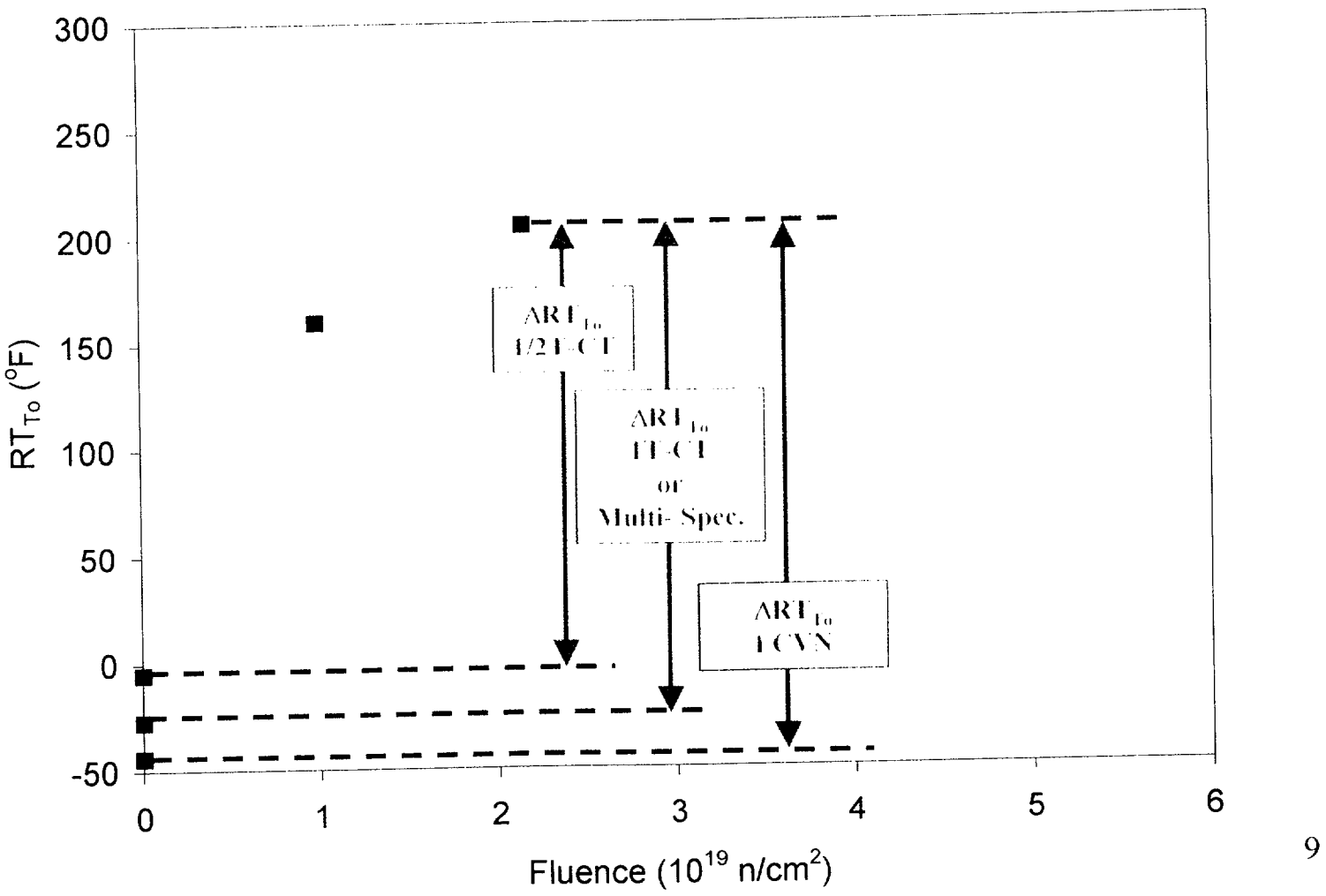
Presentation Focus: Direct Measurement is the Appropriate Analysis Method!

Shift-Based Approach to ART Determination

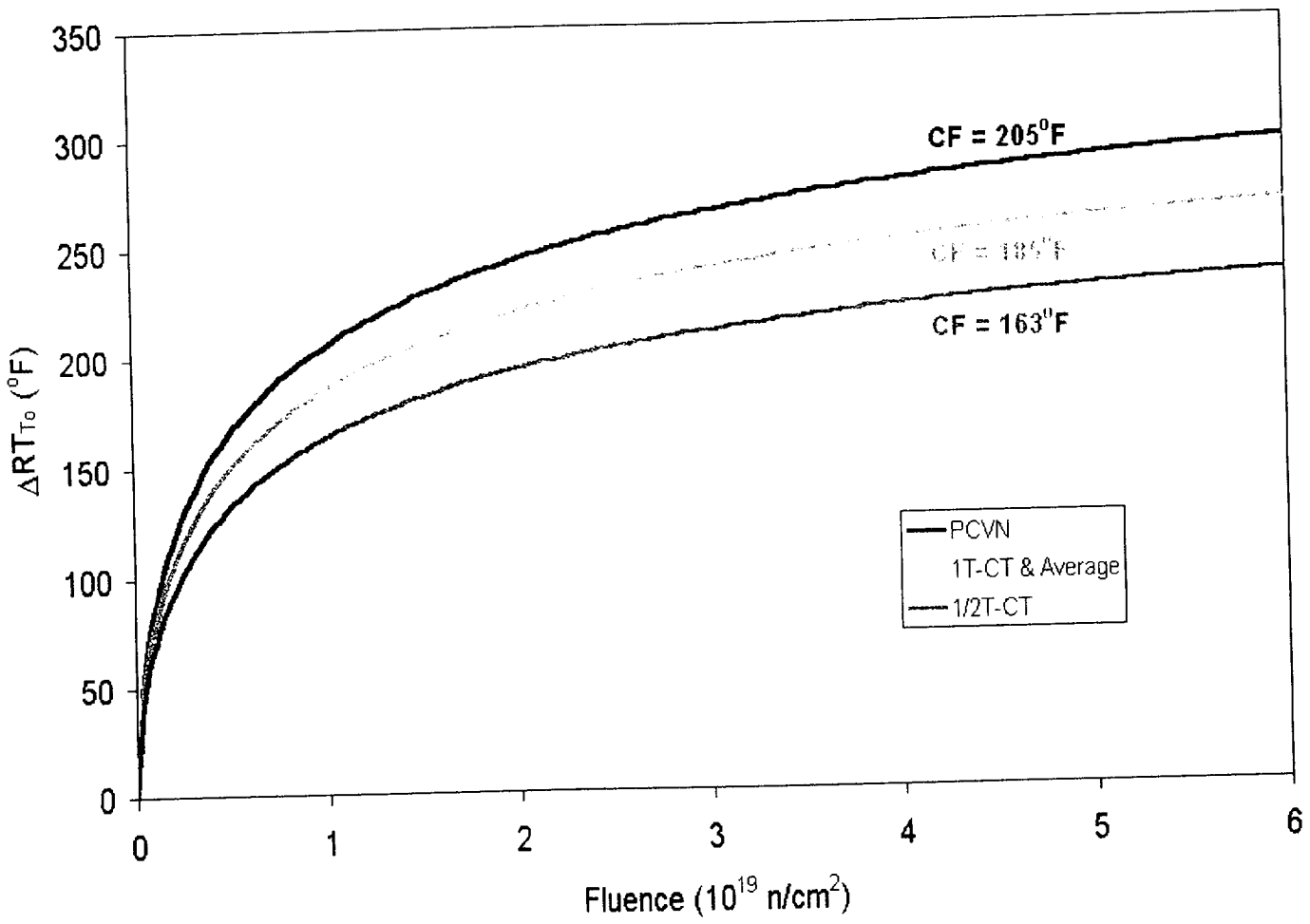


Note: *No* heat adjustment required for this plate

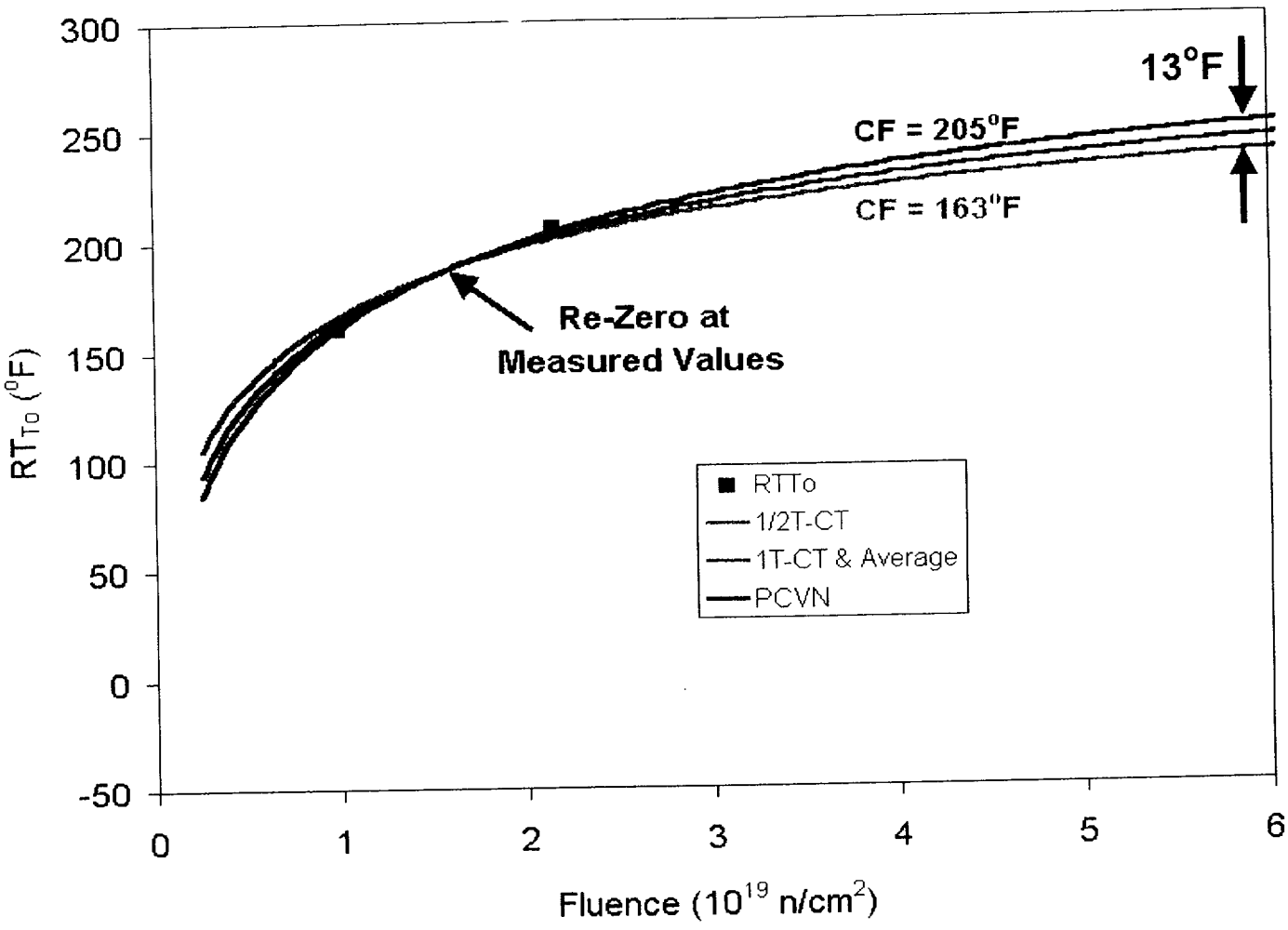
Possible RT_{To} Shift Definitions



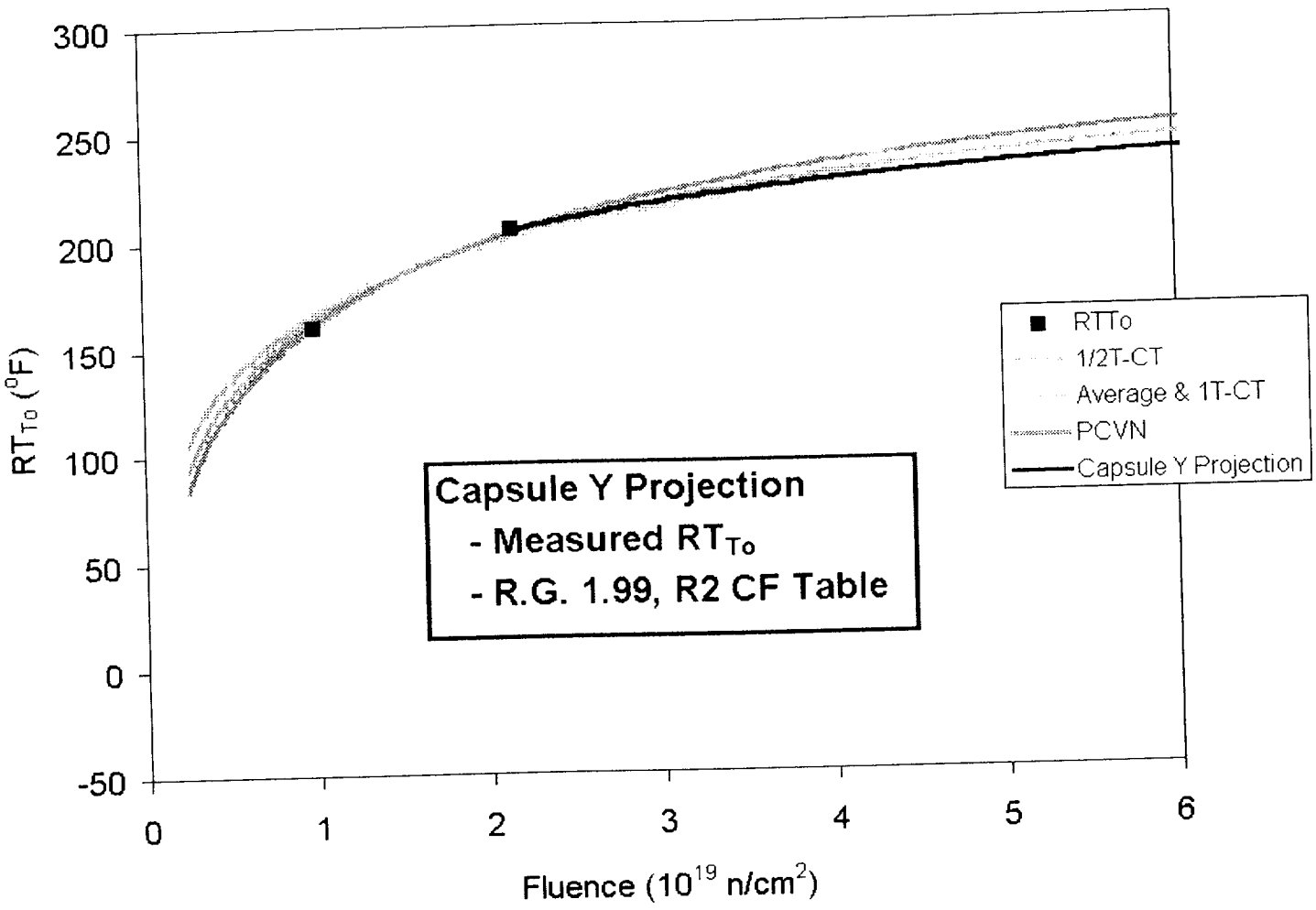
Uncertainty in Initial Value Can Cause Large Uncertainty in Shift



Uncertainty Associated With Fluence Projection is Relatively Small



Projection Does Not Require Unirradiated Data

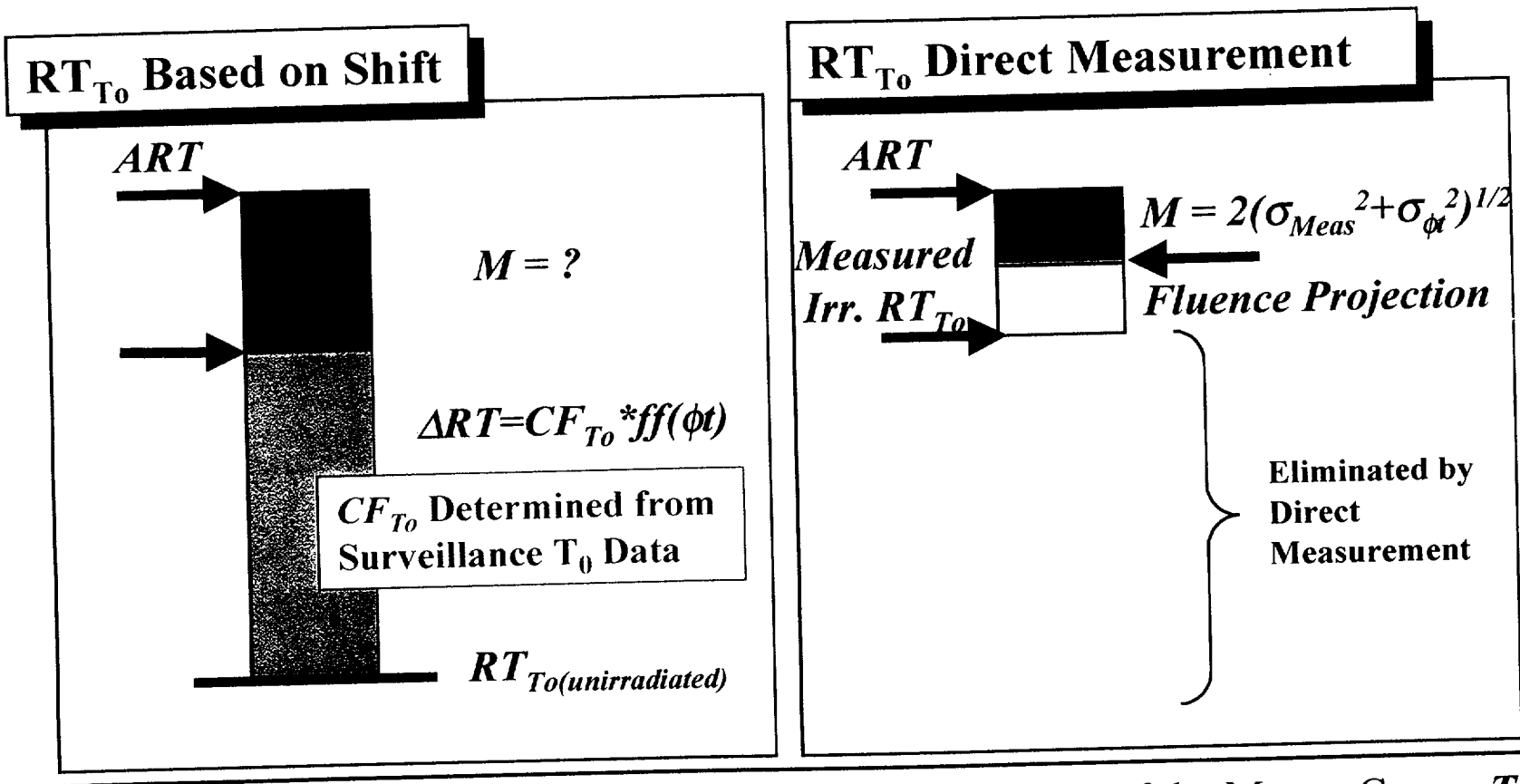


Summary of Projected Best Estimate RT_{To} Values

Unirradiated		Capsule Y		CF_{To}	Projected RT_{To} (°F)	
Source	RT_{To} (°F)	RT_{To} (°F)	ΔRT_{To} (°F)	(°F)	EOL	EOLE
1/2T-CT	-5	205	202	163	220	237
1T-CT/Average	-22	205	227	185	224	244
PCVN	-44	205	249	205	229	250
				CF_{CVN} (°F)		
PTS Rule Table	--	205	--	143	222	237

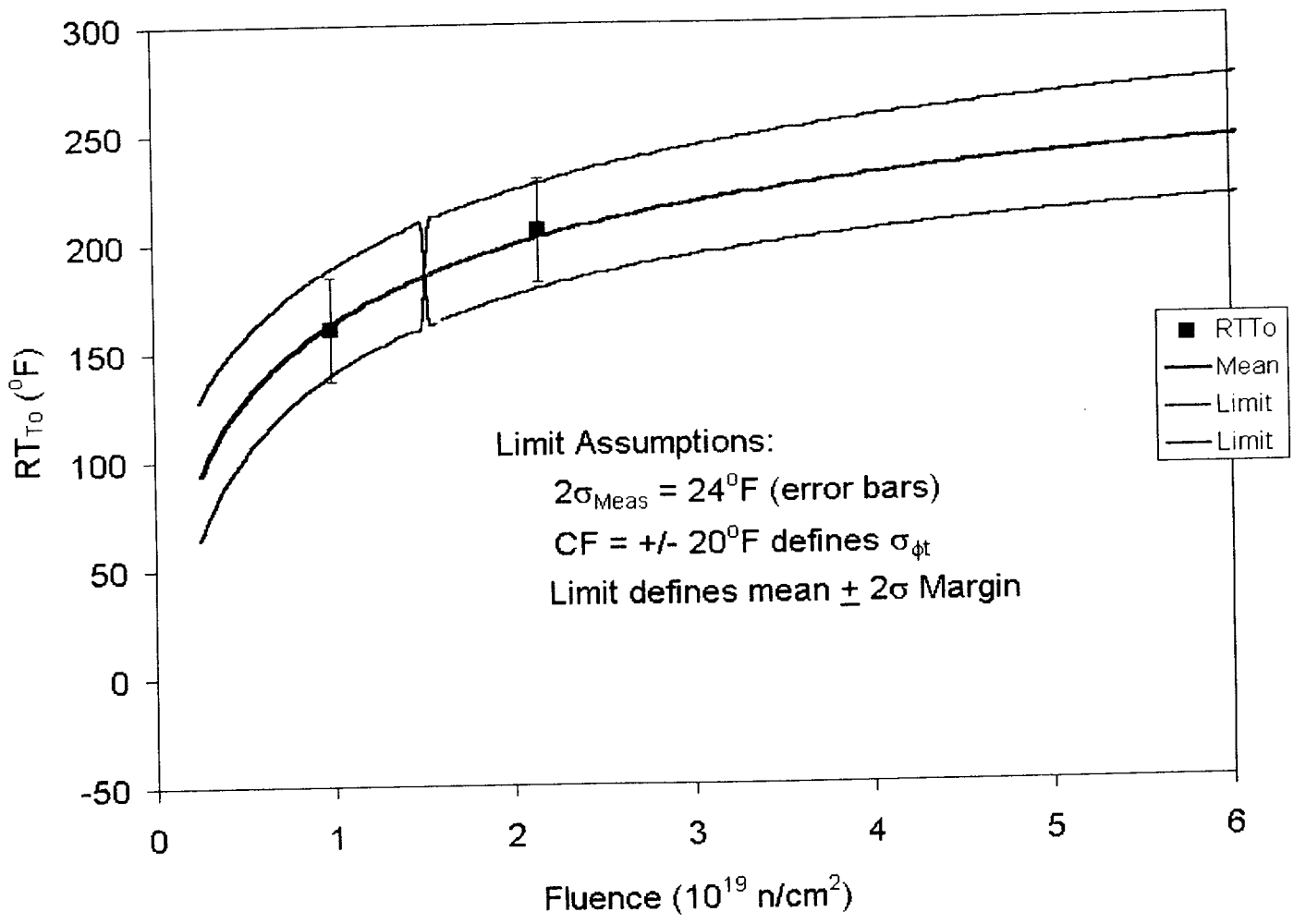
Unirradiated		@ Capsule Y		Capsule Adj.	Projected RT_{NDT} (°F)	
Source	RT_{NDT} (°F)	RT_{NDT} (°F)	ΔRT_{NDT} (°F)	CF_{CVN} (°F)	EOL	EOLE
Charpy V-notch	27	182	155	149	225	241

Advantage of Direct Measurement



Shift Based Approach Does Not Utilize the Primary Advantage of the Master Curve: ***The Ability to Directly Measure RT$_{To}$ for Irradiated Materials and Re-Zero the Starting Point for Extrapolation to EOLE***

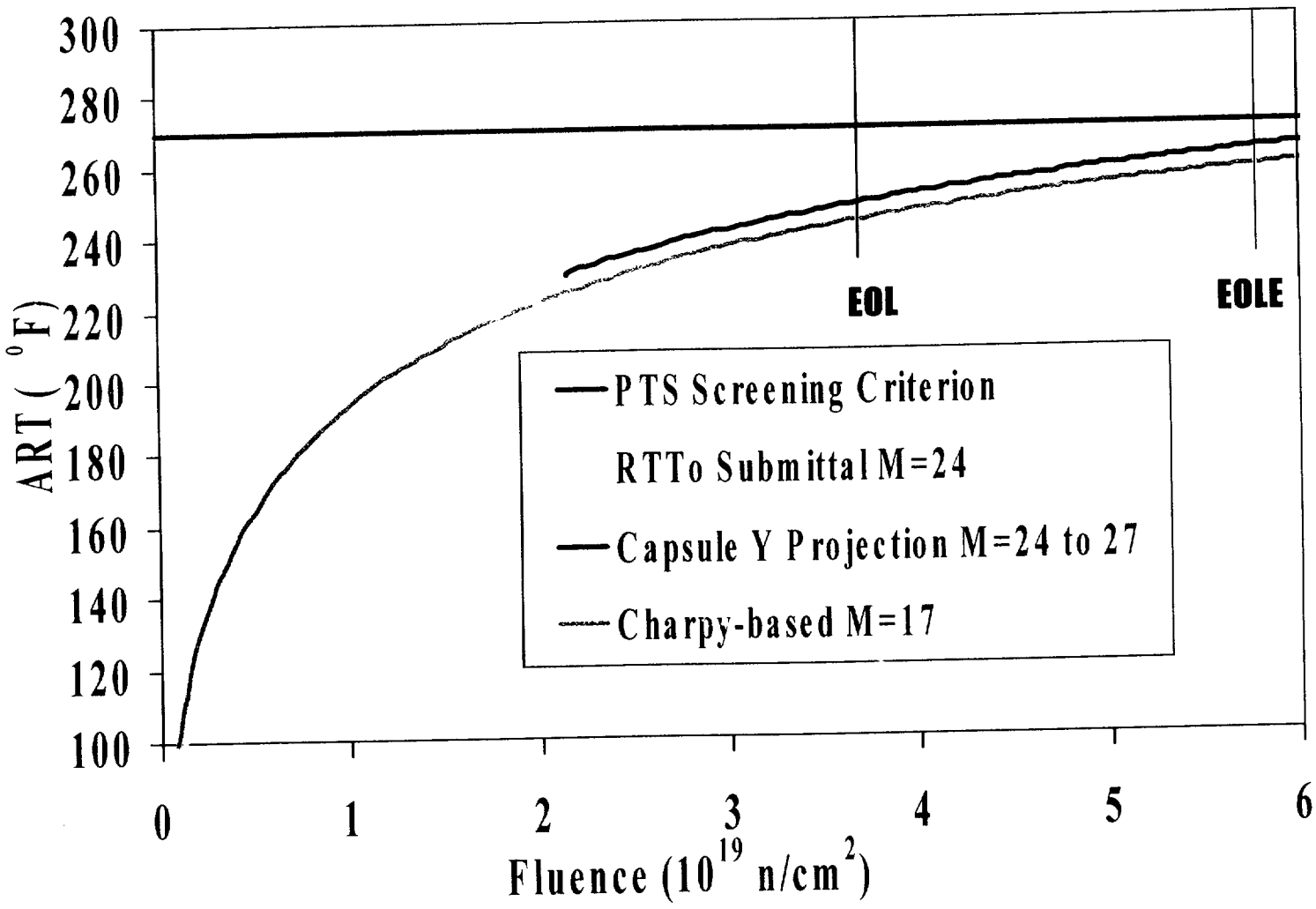
Margin Evaluation for Direct Measurement



Advantage of Using RT_{To} for the BVPS-1 Plate

- For the Irradiated BVPS-1 plate $RT_{To} \approx RT_{NDT}$
- Consistent *Best Estimates* of EOL and EOLE Reference Temperatures are obtained
  - ✓ Little difference between Charpy-based and Master Curve-based projections
  - ✓ Thus, the main benefit is confirmation of the behavior of the material using two independent measures
- The ART is determined by adding Margin to the *Best Estimate* value of Reference Temperature ....

Comparison of ART Calculations



Future Testing and Summary

- An acceptable methodology to utilize for the supplemental surveillance program data (new Capsule M in BVPS-2) and future BVPS-1 Capsule X data is needed for EOLE
  - ✓ Irradiated material from *all* beltline materials will be available in 2011 from supplemental Capsule M (being irradiated in BVPS-2) corresponding to maximum EOLE fluence for the limiting plate
  - ✓ Irradiated plate material (and surv. weld) from Capsule X will reach maximum EOLE fluence in 2017
- Confirmation of best estimate behavior between Charpy and Master Curve approaches has been achieved

Desired Outcomes

- Acceptance of Direct Measurement of Irradiated T_o / RT_{To}
- Alternative: Accept Master Curve as supplemental information demonstrating credibility of surveillance program data