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SUBJECT: Forwards response to request for addl info related to proposed changes to Nine Mile Point Unit 1 re pressure-temp limits.Nonproprietary version of Final Rept MPM-59401-NP encl also.

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B. Ralph Sylvia
Executive Vice President
Nuclear

December 20, 1994
NMP1L 0888

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

RE: Nine Mile Point Unit 1
Docket No. 50-220
DPR-63

Subject: *Proposed License Amendment - New Pressure-Temperature Limit Curves, Response to Request for Additional Information*

Gentlemen:

In a letter to the Nuclear Regulatory Commission (NRC) dated September 1, 1994 (NMP1L 0858), Niagara Mohawk Power Corporation (NMPC) proposed a Technical Specification amendment to Section 3.2.2 changing the pressure-temperature limit curves in Figures 3.2.2.a, b, c, d, and e. During the Staff's review of the proposed amendment, they determined that additional information is required to complete their review. The additional information was specified in a November 21, 1994 letter to NMPC and clarified in a telephone conference on December 1, 1994. On December 5, 1994, NMPC submitted to the NRC a proprietary copy of the "Plant Specific Charpy Shift Model for Nine Mile Point Unit 1." This letter contains additional information requested in NRC's November 21, 1994 letter. Attached to this letter are: 1) Response to NRC Additional Information Request Related to Proposed Changes to Nine Mile Point Unit 1 (NMP-1) Pressure-Temperature Limits; 2) a non-proprietary version of the "Plant Specific Charpy Shift Model for Nine Mile Point Unit 1"; and 3) a waiver of Copyright Restrictions for the non-proprietary report.

NMPC has provided a copy of this response to the appropriate state representative.

Very truly yours,

B Ralph Sylvia

B. Ralph Sylvia
Executive Vice President - Nuclear

BRS/RLM/lmc
Attachments

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PDR ADOCK 05000220
P PDR

A001

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Attachment 1

Response to NRC Additional Information Request Related to Proposed Changes to Nine Mile Point Unit 1 (NMP-1) Pressure-Temperature Limits

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Information Request A - "For the surveillance plate material, Criteria 1 of RG 1.99, Rev. 2 was not met because the limiting material (upper plate G-307-4) is not the surveillance material. Criteria 3 was not met because the method described in Regulatory Position 2.1 was not used to obtain the best-fit line of the plant-specific data. Verify and provide the basis for determining that the surveillance data are credible."

NMPC Response - Prior to the development of the plant-specific Charpy shift model, NMPC took steps to bring the NMP-1 surveillance program into conformance with the current version of ASTM E185 and with Section III of the ASME code. The program modifications were fully described in Reference [Ma92] along with a discussion of how the upgraded surveillance program data satisfies the five criteria of Regulatory Guide 1.99 (Rev. 2) (RG 1.99(2)).

With regard to Criterion 1, it was pointed out in [Ma92] that the Cu and Ni content of the surveillance plate materials closely matches the plate G-307-4 chemistry and a small chemistry adjustment factor, based on the RG1.99(2) model, was used in the past to represent the G-307-4 behavior. However, as a result of the development of the plant-specific model, it was observed that Cu does not play a significant role at fast fluences below $\sim 2\text{x}10^{18}$ n/cm^2. Therefore, there is no need for a chemistry adjustment and the NMP-1 surveillance data are credible in terms of their representation of the G-307-4 behavior under irradiation.

With regard to Criterion 3, the RG1.99(2) model was used in the past to demonstrate the credibility of the NMP-1 surveillance data in terms of its scatter about the mean. A discussion of this analysis using the RG1.99(2) model was provided in Reference [Ma92]. As shown in Figure 4-14 of Reference [Ma94], the NMP-1 data fall within the scatter of the plant-specific data. Therefore, the NMP-1 surveillance data are credible with regard to RG1.99(2) Criterion 3 under the plant-specific analysis as well.

Information Request B - "For equation (2-2) on Page 5 of the submittal (calculation of ΔRT_{NDT} for the beltline plate material);

(1) Identify all raw data used to arrive at this equation."

NMPC Response - The NRC's Power Reactor Embrittlement Database (PR-EDB) was the source of all data used to obtain equation (2-2) on Page 5 of the submittal. The data used in the regression analysis are listed in Table 4-1 of Reference [Ma94].

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Information Request C - "Figure 2-1 on Page 11 of the submittal compares the RG 1.99, Rev. 2 model with the plant specific ΔRT_{NDT} model. For each data point:

(1) Provide the copper and nickel content,
(2) Identify the plant from which each data point was obtained, and
(3) Identify which data were not used in development of the curve."

NMPC Response - The Cu and Ni content of the data plotted in Figure 2-1 on Page 11 of the submittal is given in Table 1. The Cu content of the data in Table 1 was plotted versus the square root of fluence in Figures 4-10 through 4-12 of Reference [Ma94]. These plots demonstrate the lack of Cu dependence at fluences below $\sim 2 \times 10^{18}$ n/cm^2.

The data used in the regression model included fluences up to 4×10^{18} n/cm^2. These data are indicated in Table 1.

Information Request D - "Provide the basis and data used to conclude that "... most BWRs operate at fluences below the fluence threshold for significant Cu precipitation." (Page 3 of submittal)"

NMPC Response - Since radiation damage in RPV steels causes an increase in yield and ultimate tensile stress, tensile data analysis is an effective means for studying the microstructural evolution under irradiation. Irradiation produces both shearable (Mn/Cu/Ni and possibly Si rich clusters, depleted zones, and vacancy loops) and non-shearable (Mo_2C) hardening defects, and it is important to resolve whether the shearable or non-shearable contribution is greater in order to be able to adequately model the effect on fracture behavior. For this purpose, a study of tensile data trends, originally reported in Reference [Ma92b] and later expanded in [Ma94b] and [Ma94c], is particularly relevant.

Figure 1 shows that elevation of the yield strength occurs for Cu levels above ~0.1 weight percent. This is consistent with the Transmission Electron Microscopy (TEM), Atom Probe-Field Ion Microscopy (APFIM), and Small Angle Neutron Scattering (SANS) data reported in Reference [Au94]. The change in yield strength as a function of fluence and Cu content is shown in Figures 2 through 5. As shown in Figure 3, for fluences $< 1 \times 10^{18}$ n/cm^2, there is no significant dependence of Cu level on the yield strength elevation. Figure 6 shows the ΔT_{30} and ΔUSE correlation with elevation of yield strength ($\Delta\sigma_y$). The correlation of $\Delta\sigma_y$ with ΔT_{30} is a reflection of the neutron induced formation of fine scale dislocation obstacles which increase the flow stress and produce more intense localized plastic zones at elevated temperature. This correlation is physically meaningful. However, the correlation of ΔUSE with $\Delta\sigma_y$ is an indirect correlation. The drop in USE is not directly related with hardening. Rather, flow localization due to the introduction of shearable defects is the most plausible explanation for the shelf drop [Ma94b]. The fact that the ΔUSE correlates with $\Delta\sigma_y$ is merely a reflection that $\Delta\sigma_y$ is proportional to the number density of shearable defects.

Figures 7 through 9 are the trends for strain hardening. Figure 7 shows that the yield stress and the ultimate stress are elevated by approximately the same amount. There is a small trend for the irradiated yield stress to increase more than the irradiated ultimate stress.

The uniform strain trend is shown in Figure 8. Overall, the change in uniform strain after irradiation is small and there is a trend toward decrease in ductility after irradiation. As shown in Figure 9, there does not appear to be a significant change in the strain hardening. The data in Figure 9 were obtained by idealizing the flow curve as a bilinear approximation. The negligible change in strain hardening suggests that the primary hardening defects are shearable (e.g., vacancy loops, solute clusters). Non-shearable particle (e.g., Mo_2C) distributions are apparently not significantly changed or the particles formed during irradiation are not sufficiently large to cause dislocation looping.

In addition to the tensile data trends, further evidence of a lack of Cu dependence at fluences below $\sim 2x10^{18}$ n/cm is shown in Figures 10-12. There is no apparent trend in Charpy shift with fast fluence in these figures.

Finally, APFIM studies [Au94, Mi88, Mi88b] have shown definitively that the concept of a pure copper precipitates in RPV steels is incorrect. These studies have shown that clusters, or "clouds", of elements like Ni, Mn, Si, and Cu actually form. It has been shown that Cu only plays a minor role. In Reference [Au94], it was concluded that clustering occurred in the first stage of formation at a fluence of $4.6x10^{19}$ n/cm^2. Therefore, based on APFIM results, future generic trend curves should consider the effect of other elements such as Si, Mn, and P, and should account for an incubation dose for significant clustering effects on mechanical behavior. In the absence of physically correct generic trend curves, an accurate approach is to develop a plant-specific trend curve as described in [Ma94].

Information Request E - "Provide the basis for using a margin of 17°F as opposed to 34°F as specified in RG 1.99 in the calculation of the adjusted reference temperature for the beltline plates."

NMPC Response - The RG1.99(2) σ_I term for plates was taken to be 0 because the initial RT_{NDT} was determined based on measured data as described in Reference [Ma92]. The σ_Δ term prescribed in RG1.99(2) adds conservatism to the ART_{NDT} to account for uncertainty in the Charpy shift regression model. This uncertainty comes from test method variation and from variation in the fracture behavior of the material. Therefore, since the σ_Δ term of 17°F for the base metal was determined using a large data population, this value was used in the calculation of the RG1.99(2) margin term since it is expected to represent Charpy data scatter better than that obtained from a small data population. Under Section 2.1 of RG1.99(2), the σ_Δ term may be cut in half for plants which have 2 or more credible data sets. Since the plant-specific model developed is consistent with the intent of Section 2.1 of RG1.99(2), the RG1.99(2) σ_Δ term was halved.

Information Request F - "Provide applicable information, with respect to questions 1-6 above, regarding the beltline welds."

NMPC Response - This request was deleted during a telephone conference with the NRC on December 1, 1994.

The NRC requested the following information:

- σ_I and σ_Δ used for the weld margin term calculation.
- Standard deviation for the plant-specific plate model.

NMPC Response - As discussed in Reference [Ma92], σ_I for welds was taken to be 17°F and σ_Δ was one-half of the ΔRT_{NDT}.

In response to the NRC request, the standard deviation (σ) for the plant-specific plate model was calculated and found to be 32°F. The mean regression line and 2σ confidence limits are shown in Figure 13. It is NMPC's position that the most appropriate σ_Δ is that of RG1.99(2) (17°F) because it was calculated based on a large data population and more accurately reflects the uncertainty in Charpy shift (ΔT_{30}) measurement and material variation. Further justification for use of the RG1.99(2) σ_Δ term is provided by considering the variation in the NMP-1 surveillance data. The average for the three NMP-1 ΔT_{30}s is 48.5°F. The difference between this average and the peak ΔT_{30} is 30.8°F. The difference between the average and the lowest ΔT_{30} is 37.3°F. These data, along with the data presented in Table 1, demonstrate the lack of dependence on Cu in the low fluence range and also suggest that the RG1.99(2) 2σ limit (34°F) reasonably represents the uncertainty for the NMP-1 beltline plates.

Table 1 Cu and Ni Content of Data Plotted in Figure 2-1 of the Submittal

Plant ID	Material	Cu (wt.%)	Ni (wt.%)	Charpy Shift ΔT_{30} (ft.-lbs.)	Square Root of Best Estimate Fluence x 10^8 (n/cm^2)	Used in Regression Model
Big Rock Point	A302B	0.10	0.18	0	12.00	yes
Big Rock Point	A302B	—	—	15	12.00	yes
Big Rock Point	A302B	—	—	15	12.00	yes
Haddam Neck	A302B	0.10	—	35	14.39	yes
Haddam Neck	A302B	0.12	—	85	14.39	yes
Haddam Neck	A302B	0.12	—	80	20.10	yes
Garigliano	A302B	0.23	—	106	27.15	no
Garigliano	A302B	0.23	—	167	68.19	no
Garigliano	A302B	0.23	—	115	47.01	no
Garigliano	A302B	0.23	—	126	33.17	no
Garigliano	A302B	0.23	—	151	73.96	no
Oyster Creek	A302B	0.17	0.11	72	8.64	yes
Point Beach 1	A302B	0.20	0.06	90	22.89	yes
Point Beach 1	A302B	0.20	0.06	100	48.68	no
Point Beach 1	A302B	0.20	0.06	90	28.25	no
Point Beach 1	A302B	0.20	0.06	105	48.58	no
San Onofre 1	A302B	0.18	—	130	58.99	no
San Onofre 1	A302B	0.18	—	100	41.83	no

Table 1 Cu and Ni Content of Data Plotted in Figure 2-1 of the Submittal (Cont'd)

Plant ID	Material	Cu (wt.%)	Ni (wt.%)	Charpy Shift ΔT_{30} (ft.-lbs.)	Square Root of Best Estimate Fluence x 10^8 (n/cm^2)	Used in Regression Model
San Onofre 1	A302B	0.18	—	100	41.83	no
San Onofre 1	A302B	0.18	—	110	58.99	no
San Onofre 1	A302B	0.18	—	120	62.05	no
Indian Point 3	A302M	0.19	0.49	150	32.25	no
Indian Point 3	A302M	0.24	0.52	137	17.66	yes
Indian Point 3	A302M	0.24	0.52	150	26.91	no
Indian Point 3	A302M	0.18	0.50	89	17.66	yes
Indian Point 3	A302M	0.24	0.52	118	17.66	yes
Indian Point 3	A302M	0.24	0.52	155	32.25	no
Indian Point 3	A302M	0.24	0.52	170	32.25	no
Millstone 1	A302M	0.21	0.59	58	5.70	yes
Nine Mile Point 1	A302M	0.18	0.56	11	6.91	yes
Nine Mile Point 1	A302M	0.23	0.51	79	6.91	yes
Nine Mile Point 1	A302M	0.23	0.51	55	6.00	yes
Palisades	A302M	0.24	0.53	205	67.08	no
Palisades	A302M	0.24	0.53	175	33.17	no

Table 1 Cu and Ni Content of Data Plotted in Figure 2-1 of the Submittal (Cont'd)

Plant ID	Material	Cu (wt.%)	Ni (wt.%)	Charpy Shift ΔT_{30} (ft.-lbs.)	Square Root of Best Estimate Fluence x 10^8 (n/cm^2)	Used in Regression Model
Palisades	A302M	0.24	0.53	205	66.33	no
Palisades	A302M	0.24	0.53	155	33.62	no
Peach Bottom 2	A302M	0.10	0.54	30	4.96	yes
Peach Bottom 3	A302M	0.13	0.62	16	4.03	yes
Beaver Valley 1	A533B	0.20	0.54	130	16.76	yes
Beaver Valley 1	A533B	0.20	0.54	150	30.22	no
Beaver Valley 1	A533B	0.20	0.54	185	30.22	no
Beaver Valley 1	A533B	0.20	0.54	140	16.76	yes
Beaver Valley 1	A533B	0.20	0.54	120	25.57	no
Beaver Valley 1	A533B	0.20	0.54	135	25.57	no
Calvert Cliffs 1	A533B	0.18	0.65	88	24.29	no
Calvert Cliffs 2	A533B	0.18	0.65	128	28.53	no
Donald C. Cook 1	A533B	0.14	0.49	70	16.40	yes
Donald C. Cook 1	A533B	0.14	0.49	60	16.40	yes
Donald C. Cook 1	A533B	0.16	0.65	60	16.40	yes
Cooper	A533B	0.22	0.76	74	6.00	yes
Crystal River 3	A533B	0.20	0.54	128	32.86	no

Table 1 Cu and Ni Content of Data Plotted in Figure 2-1 of the Submittal (Cont'd)

Plant ID	Material	Cu (wt.%)	Ni (wt.%)	Charpy Shift ΔT_{30} (ft.-lbs.)	Square Root of Best Estimate Fluence x 10^{8} (n/cm^2)	Used in Regression Model
Crystal River 3	A533B	0.20	0.54	21	10.25	yes
Crystal River 3	A533B	0.20	0.54	126	25.61	no
Crystal River 3	A533B	0.20	0.54	97	27.39	no
Crystal River 3	A533B	0.20	0.54	127	25.61	no
Duane Arnold 1	A533B	0.15	0.67	42	8.83	yes
Joseph M. Farley 2	A533B	0.20	0.60	180	54.96	no
Joseph M. Farley 2	A533B	0.20	0.60	165	40.87	no
Joseph M. Farley 2	A533B	0.20	0.60	165	40.87	no
Joseph M. Farley 2	A533B	0.20	0.60	133	24.74	no
Joseph M. Farley 2	A533B	0.20	0.60	103	24.74	no
Joseph M. Farley 2	A533B	0.20	0.60	190	54.96	no
Fort Calhoun 1	A533B	0.18	0.65	124	21.91	no
James A. Fitzpatrick	A533B	0.12	0.63	23	6.48	yes
Edwin I. Hatch 1	A533B	0.12	0.67	58	6.16	yes
Millstone 2	A533B	0.18	0.65	141	29.73	no
Maine Yankee	A533B	0.18	0.65	150	36.06	no
Maine Yankee	A533B	0.18	0.65	160	35.36	no
Pilgrim Unit 1	A533B	0.13	0.63	25	4.79	yes

Table 1 Cu and Ni Content of Data Plotted in Figure 2-1 of the Submittal (Cont'd)

Plant ID	Material	Cu (wt.%)	Ni (wt.%)	Charpy Shift ΔT_{30} (ft.-lbs.)	Square Root of Best Estimate Fluence x 10^8 (n/cm^2)	Used in Regression Model
Salem Unit 1	A533B	0.22	0.51	110	35.07	no
Salem Unit 1	A533B	0.24	0.52	100	16.00	yes
Salem Unit 1	A533B	0.22	0.51	125	30.50	no
Salem Unit 1	A533B	0.24	0.53	100	16.00	yes
Salem Unit 1	A533B	0.24	0.53	170	30.50	no
Salem Unit 1	A533B	0.24	0.52	165	30.50	no
Salem Unit 1	A533B	0.22	0.51	75	16.00	yes
St. Lucie 1	A533B	0.18	0.65	110	26.76	no
St. Lucie 2	A533B	0.10	0.57	35	12.65	yes
St. Lucie 2	A533B	0.10	0.57	21	12.65	yes
Vermont Yankee	A533B	0.10	0.66	19	2.07	yes
Zion 1	A533B	0.12	0.49	25	18.03	yes
Zion 1	A533B	0.12	0.49	60	18.03	yes
Zion 1	A533B	0.16	0.65	66	18.03	yes
Zion 2	A533B	0.12	0.51	38	16.79	yes
Zion 2	A533B	0.12	0.51	49	16.79	yes
Zion 2	A533B	0.16	0.65	50	16.79	yes

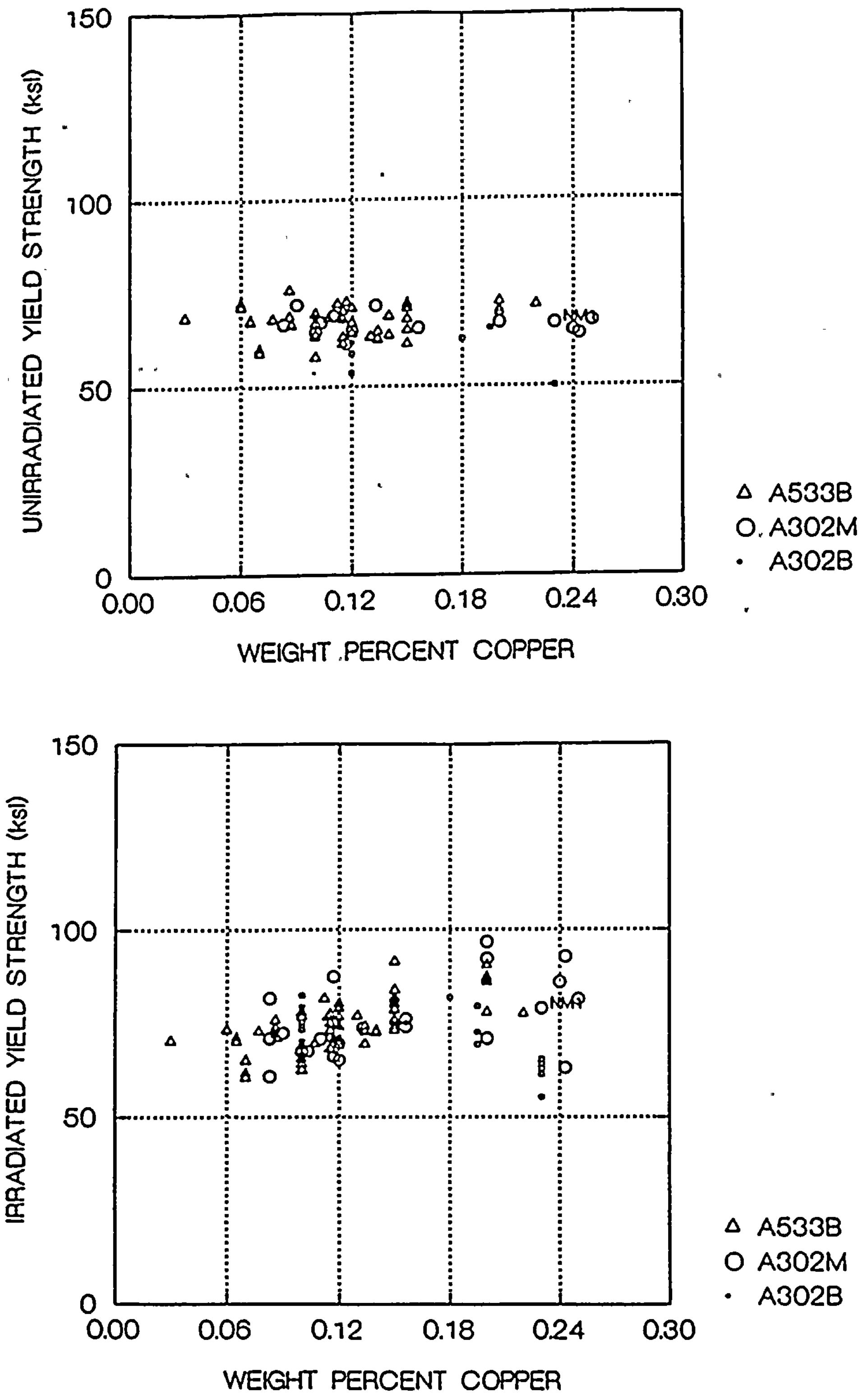


Figure 1 Unirradiated (Top) and Irradiated (Bottom) Yield Strength vs. Weight Percent Copper

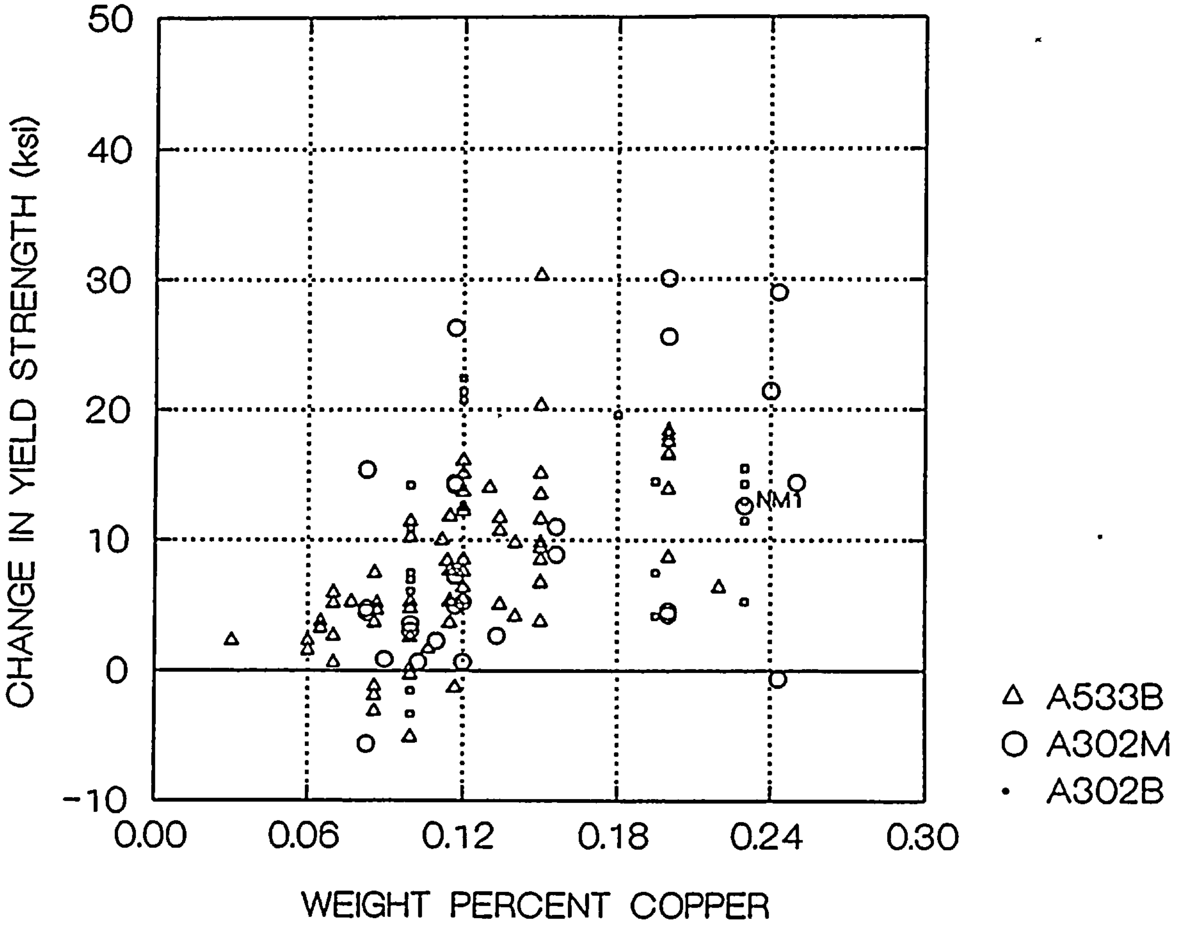


Figure 2 Yield Strength Increase as a Function of Cu Content (All Fluences)

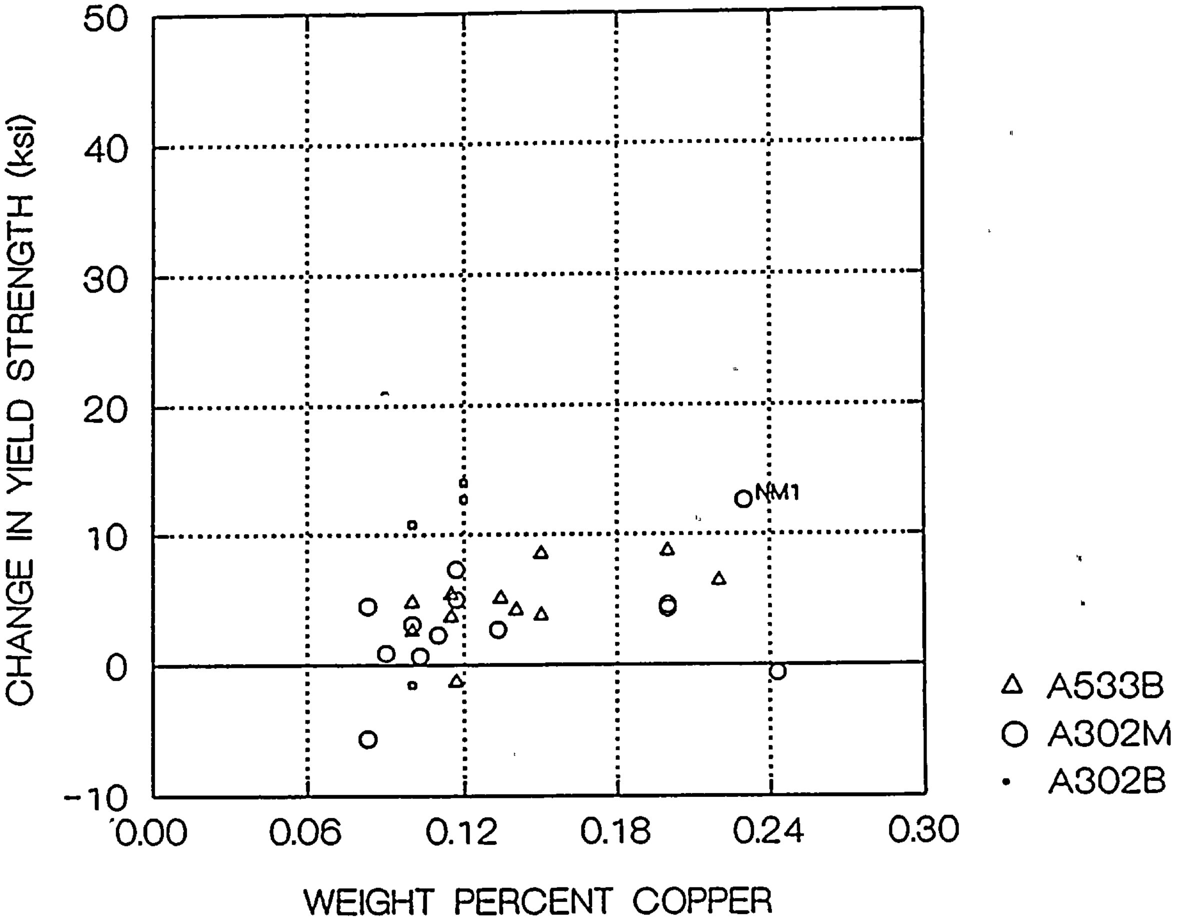


Figure 3 Yield Strength Increase as a Function of Cu Content (For Fluences < 1×10^{18} n/cm^2)

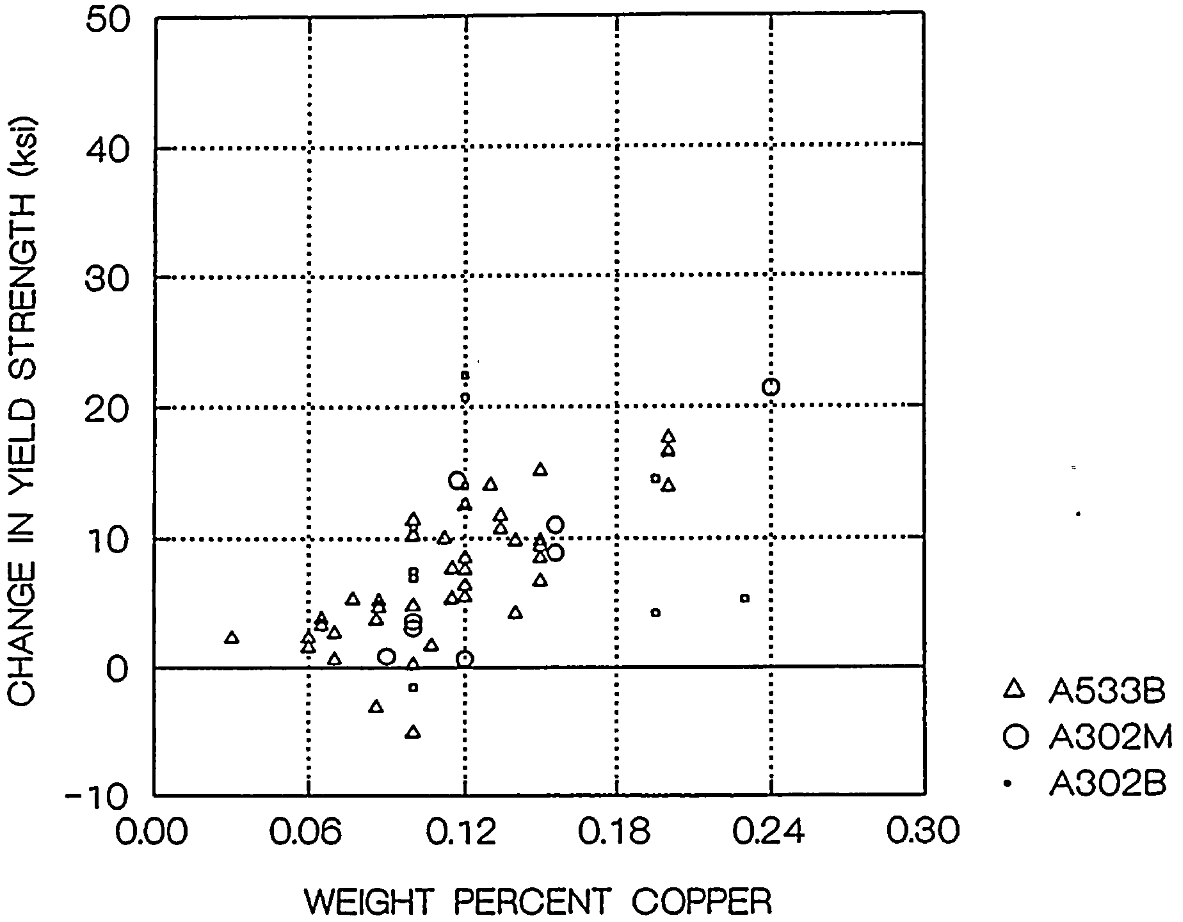


Figure 4 Yield Strength Increase as a Function of Cu Content (For Fluences in the Range $1x10^{18}$ n/cm^2 < ϕt < $1x10^{19}$ n/cm^2)

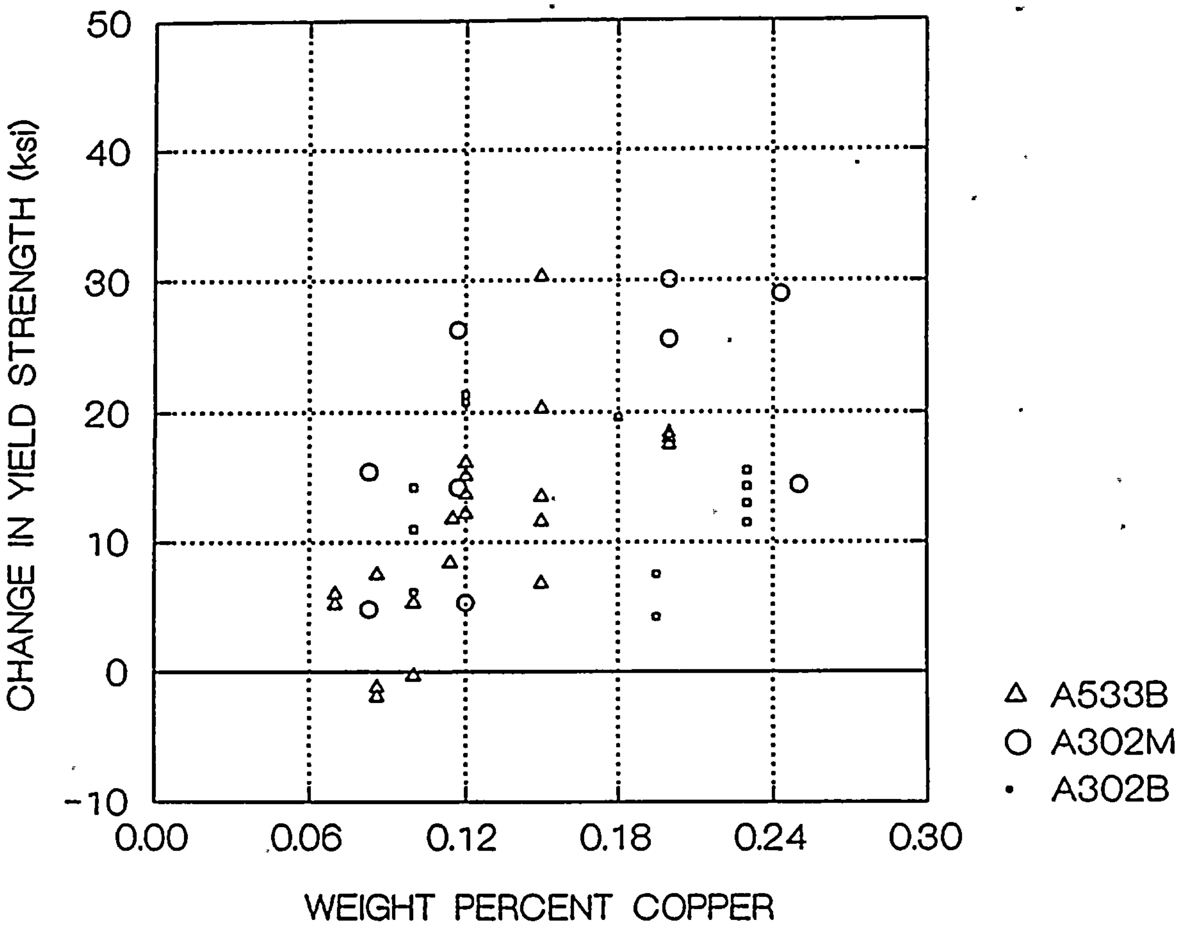


Figure 5 Yield Strength Increase as a Function of Cu Content (For Fluences > $1x10^{19}$ n/cm^2)

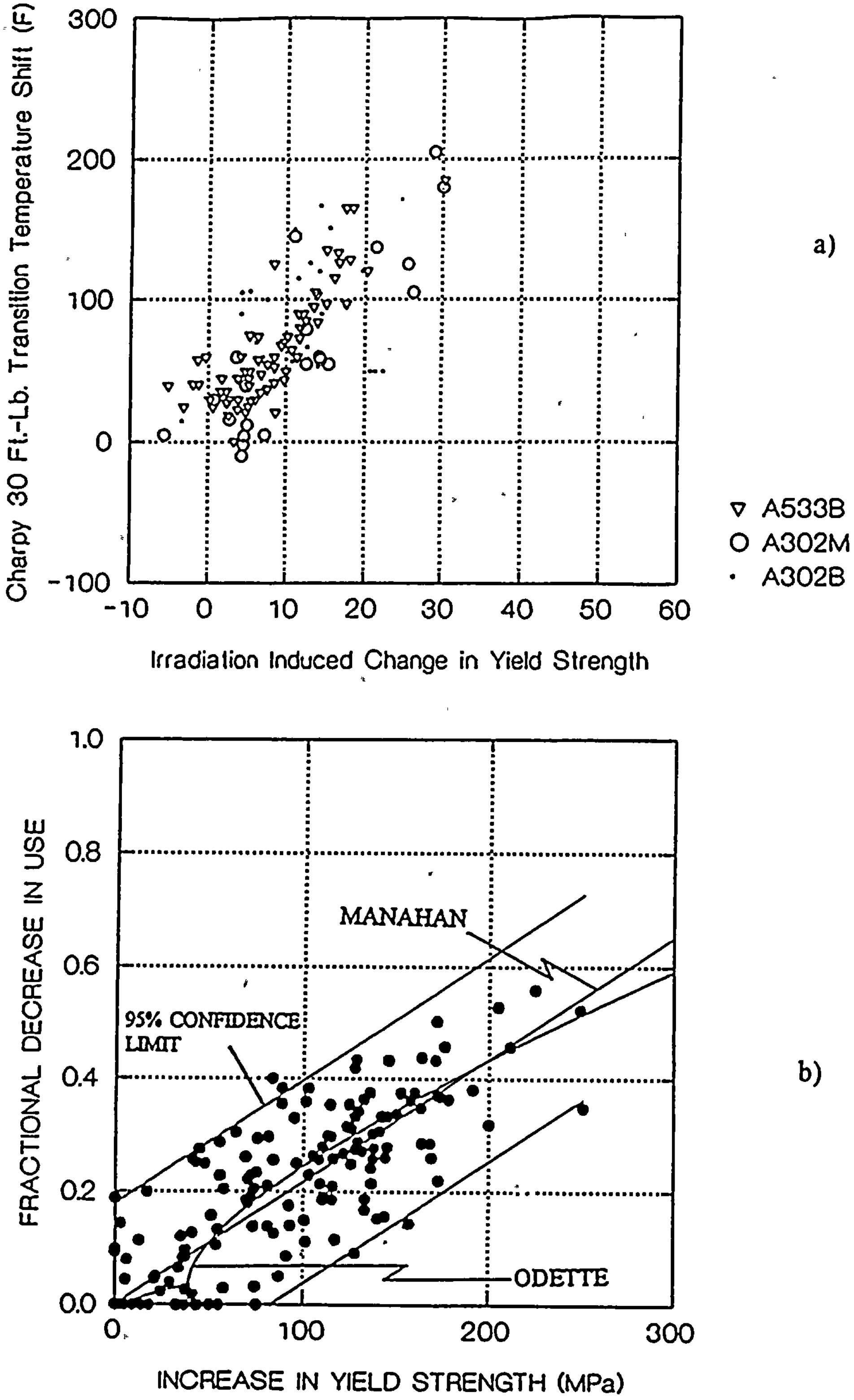


Figure 6 Correlation of Yield Strength Elevation With a) Charpy Shift and b) Fractional Decrease in USE

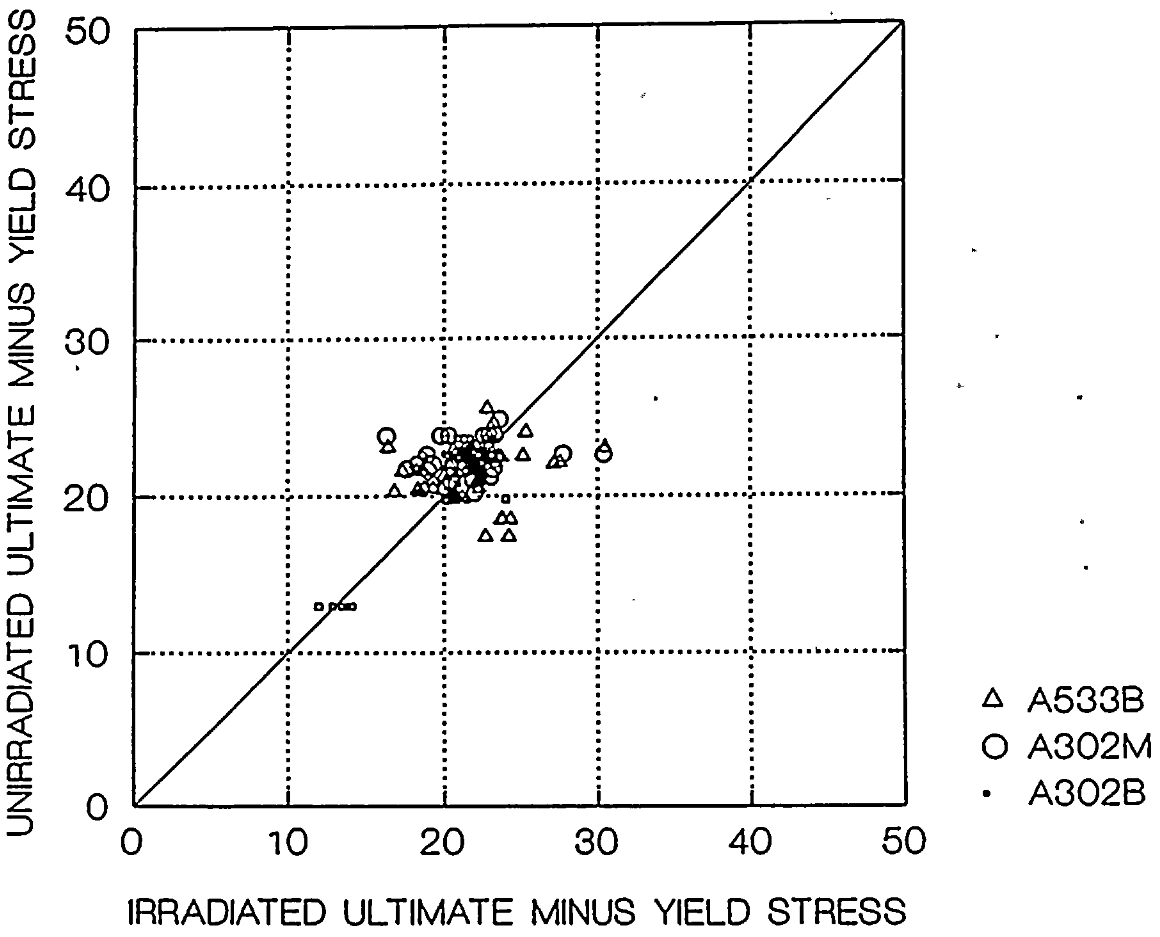


Figure 7 Plot of the Ultimate and Yield Strength Difference Before and After Irradiation

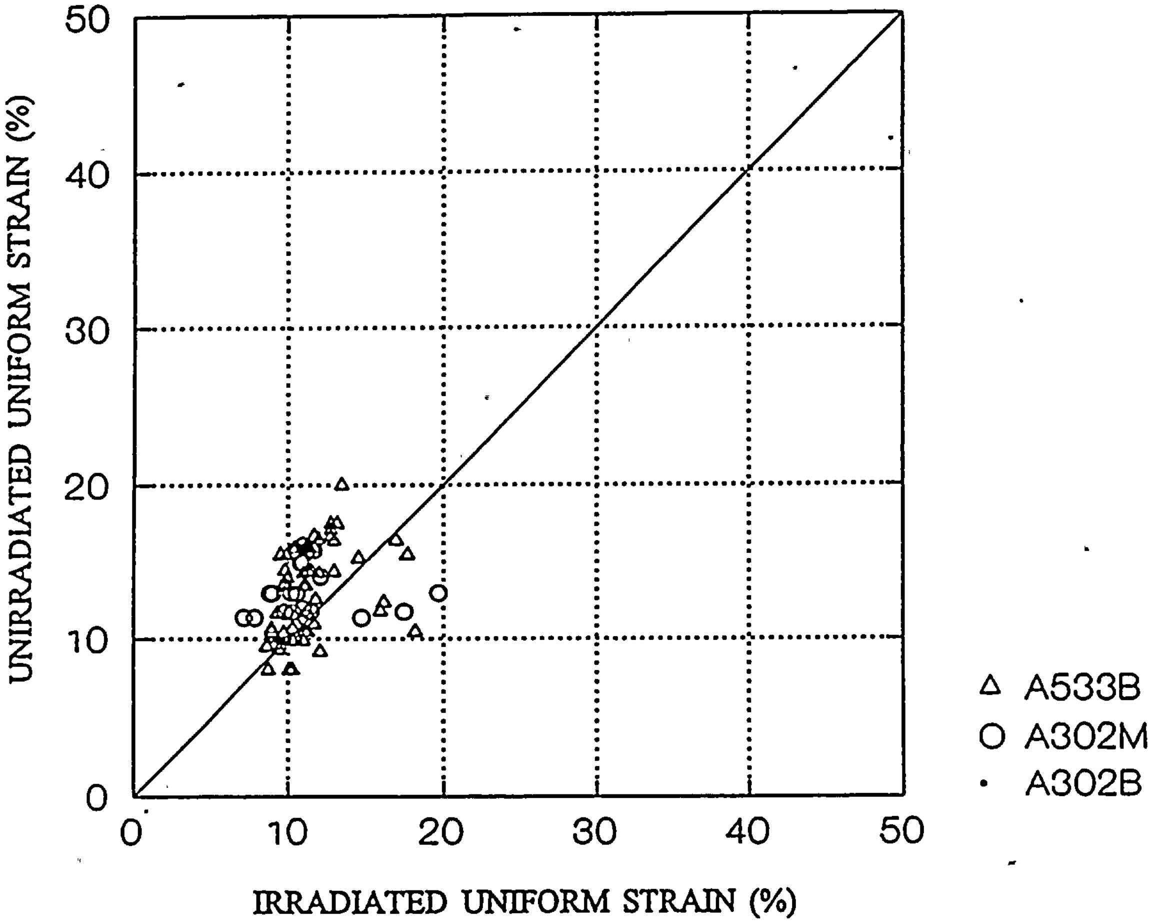
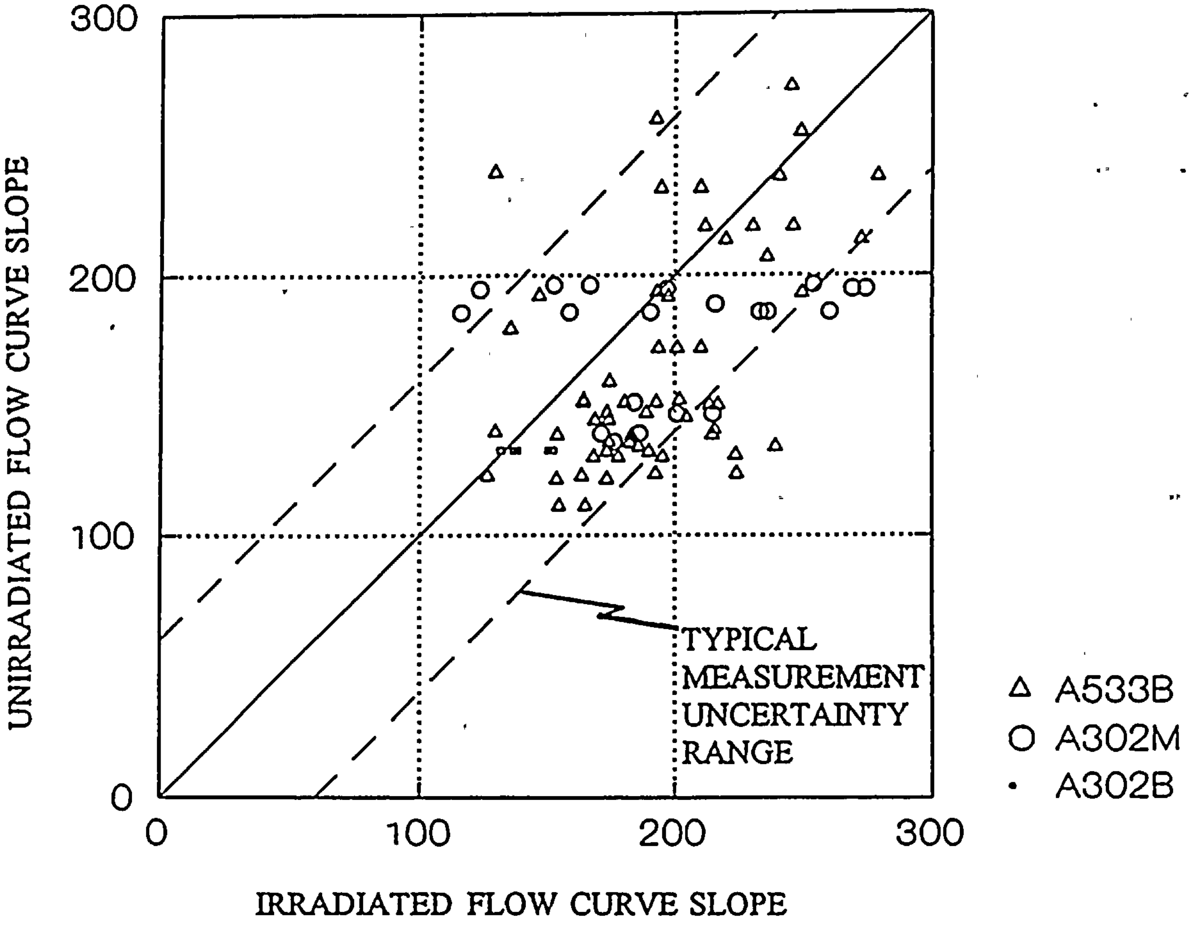


Figure 8 Plot of the Percent Uniform Strain Before and After Irradiation



$$\text{Flow Curve Slope} = \frac{UTS - YS}{e_u}$$

Figure 9 Plot of Average Flow Curve Slope Before and After Irradiation Showing Negligible Strain Hardening Change

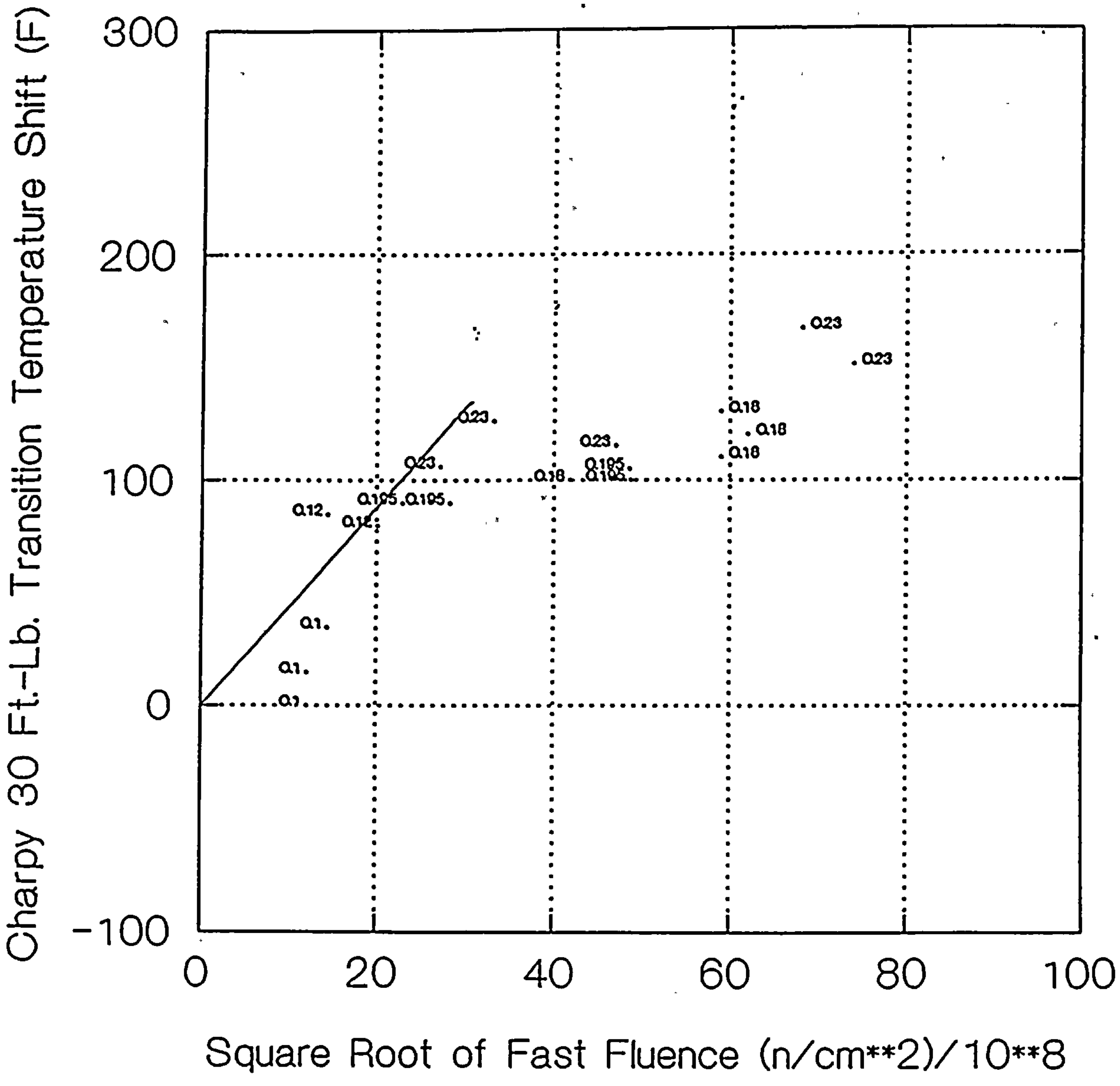


Figure 10 A302B Plant-Specific Data Set Showing Lack of Dependence of Charpy Shift on Cu Content in the Low Fluence Range. (Cu Content in Weight % Shown Next to Each Datum)

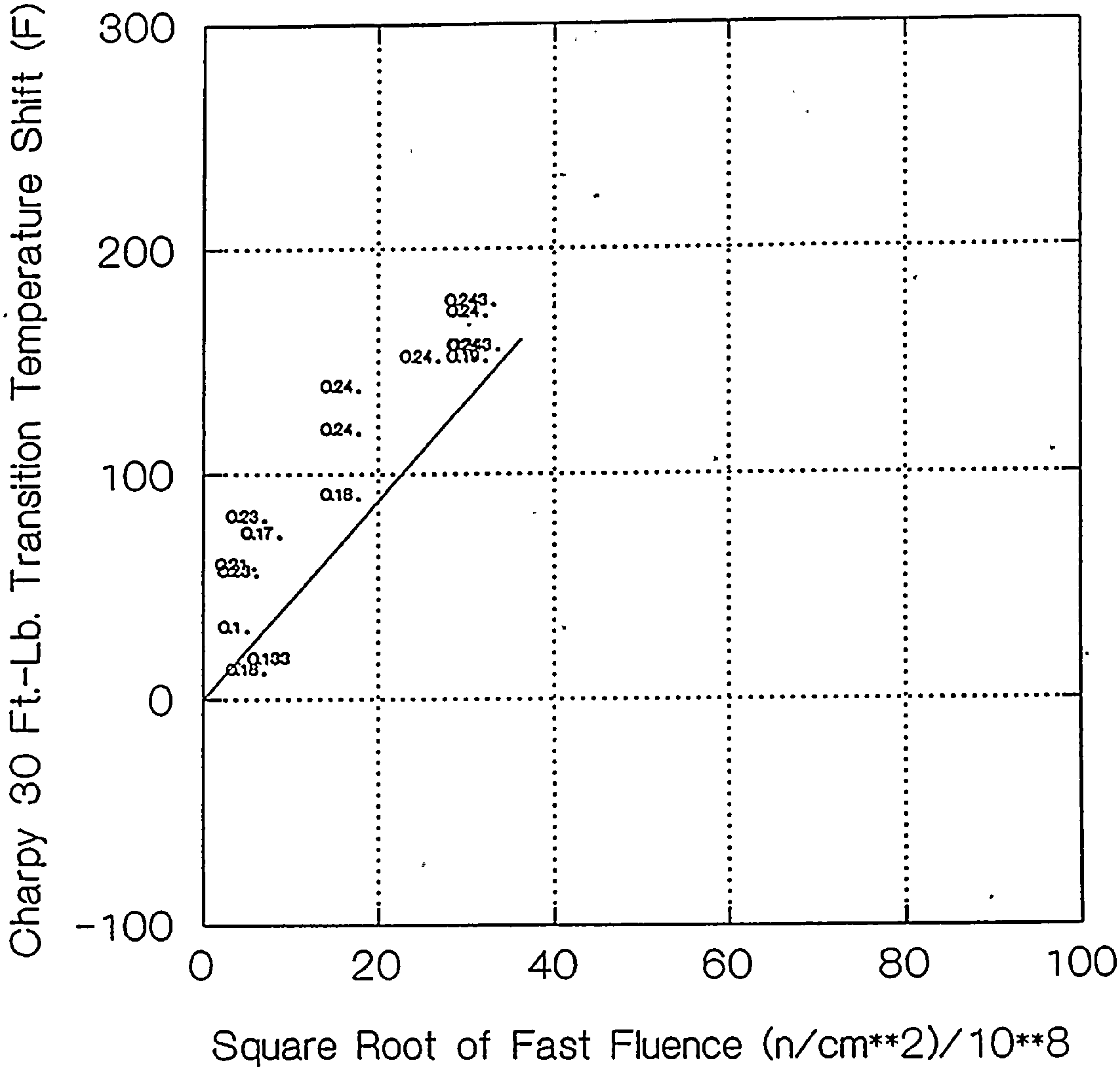
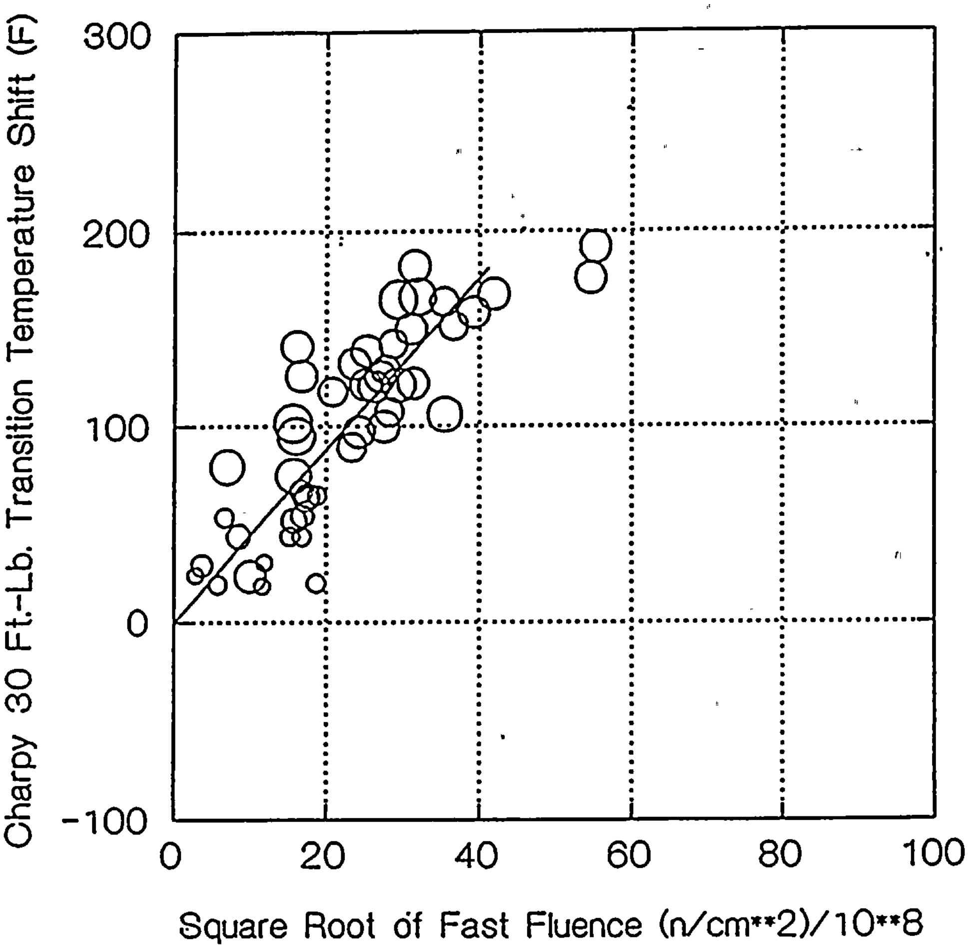


Figure 11 A302M Plant-Specific Data Set Showing Lack of Dependence of Charpy Shift on Cu Content in the Low Fluence Range. (Cu Content in Weight % Shown Next to Each Datum)



NOTE: Circle Diameters Indicate Relative Bulk Copper Content

Figure 12 A533B Plant-Specific Data Set Showing Lack of Dependence of Charpy Shift on Cu Content in the Low Fluence Range. (Cu Content Shown as Relative Circle Diameter. Larger Diameter Indicates Higher Cu Content)

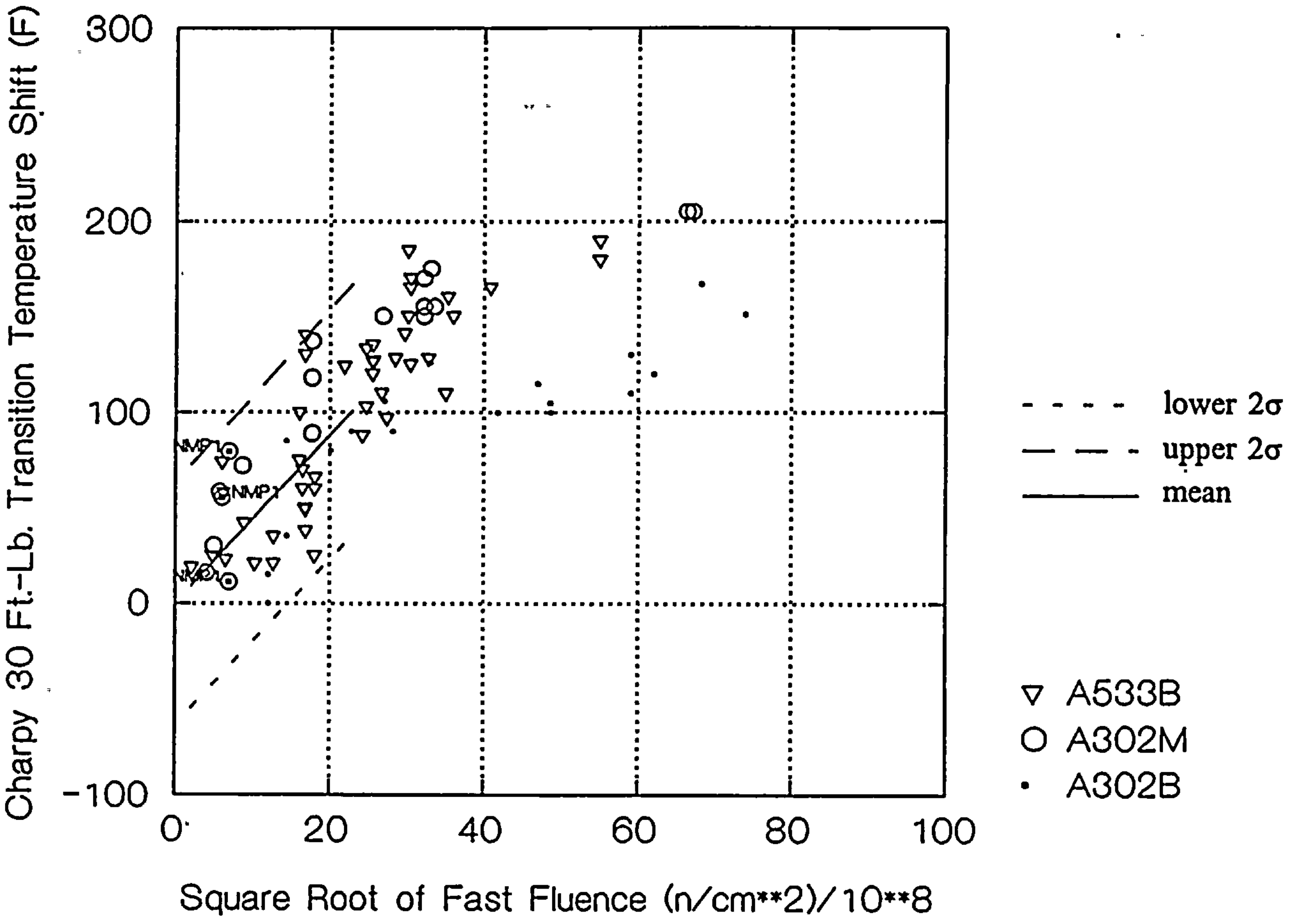


Figure 13 Plant-Specific Charpy Shift Model With 2σ Confidence Limits

References

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