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Final Status Report Confirming Completion of Mechanical Testing of HFIR Irradiated Nanocomposite Materials

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Nuclear Energy and Fuel Cycle Division

FINAL STATUS REPORT CONFIRMING COMPLETION OF MECHANICAL TESTING OF HFIR IRRADIATED NANOCOMPOSITE MATERIALS

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ABBREVIATIONS

DOE	US Department of Energy
HFIR	High Flux Isotope Reactor
IMET	Irradiated Materials Examination and Testing
INL	Idaho National Laboratory
LAMDA	Low Activation Materials Development and Analysis
MIT	Massachusetts Institute of Technology
NSUF	Nuclear Science User Facility
ORNL	Oak Ridge National Laboratory

SUMMARY

This report provides a final status report on the in-cell mechanical testing of High Flux Isotope Reactor (HFIR)-irradiated nanodispersion-strengthened materials at the Irradiated Materials Examination and Testing (IMET) facility. All tension tests were performed at room temperature with a nominal strain rate of 0.018 mm/mm/min using shoulder-loading grip sets by following the standard testing procedure in ASTM E8/E8M. Round 1 (unirradiated) and round 2 (0.7 dpa) testing was completed in FY 2021. This report confirms completion of round 3 (1.4 dpa) and round 4 (2.1 dpa) tensile testing in FY 2022 with examples of test data collected on select sample conditions. Additionally, the report includes IDs of samples selected for shipment to Idaho National Laboratory (INL) for additional characterization.

1. INTRODUCTION

The Massachusetts Institute of Technology (MIT) is studying the postirradiation properties of nanodispersion-strengthened materials for improved neutron irradiation resistance. Thirteen nanodispersion-strengthened materials were irradiated in the Oak Ridge National Laboratory (ORNL) High Flux Isotope Reactor (HFIR). Six irradiation capsules were assembled and irradiated at a target temperature of 300 ± 50°C with approximate doses of 0.7, 1.4, and 2.1 dpa (two capsules per irradiation condition) [1]. These capsules were disassembled, the thermometry was sent to the Low Activation Materials Development and Analysis (LAMDA) laboratory, and the tensile specimens were sent to cell #1 of the Irradiated Materials Examination and Testing (IMET) facility [2]. This report confirms the completion of all mechanical testing performed on the tensile specimens at IMET.

2. FINAL TESTING PERFORMED

Table 1 shows a summary of the tensile test matrix separated into multiple testing campaigns. Round 1 (unirradiated specimens) and round 2 (specimens irradiated to 0.7 dpa) testing was completed in FY 2021 [3]. The data were reviewed, analyzed, and a final test matrix confirmed for FY 2022 testing of round 3 (specimens irradiated to 1.4 dpa) and round 4 (specimens irradiated to 2.1 dpa) samples. A more detailed description of the tensile test matrix containing the specimen IDs, irradiation conditions, material type, tensile testing round, and test progress of all tensile specimens is provided in Table A-1 in Appendix A.

Round 3 and round 4 testing was conducted following the same procedures and in-cell resources as prior testing using an Instron 5965 5 kN system in cell #1 of the IMET facility. All tension tests were performed at room temperature with a nominal strain rate of 0.018 mm/mm/min using shoulder-loading grip sets. Figure 1 shows the Instron mechanical frame, and Figure 2 shows a closeup of the tensile fixture while a test is in progress. Raw load-displacement data up to failure are recorded by the Instron software and are used to determine common engineering strength and ductility parameters such as yield strength, ultimate tensile strength, uniform elongation, and total elongation. Tensile testing and data analysis were performed by following the standard testing procedure in ASTM E8/E8M.

Based on the results of mechanical testing, a list of samples (provided in Table B-1 in Appendix B) was selected for microstructural characterization at INL. The samples will be sorted and packaged for a Type A shipment this summer.

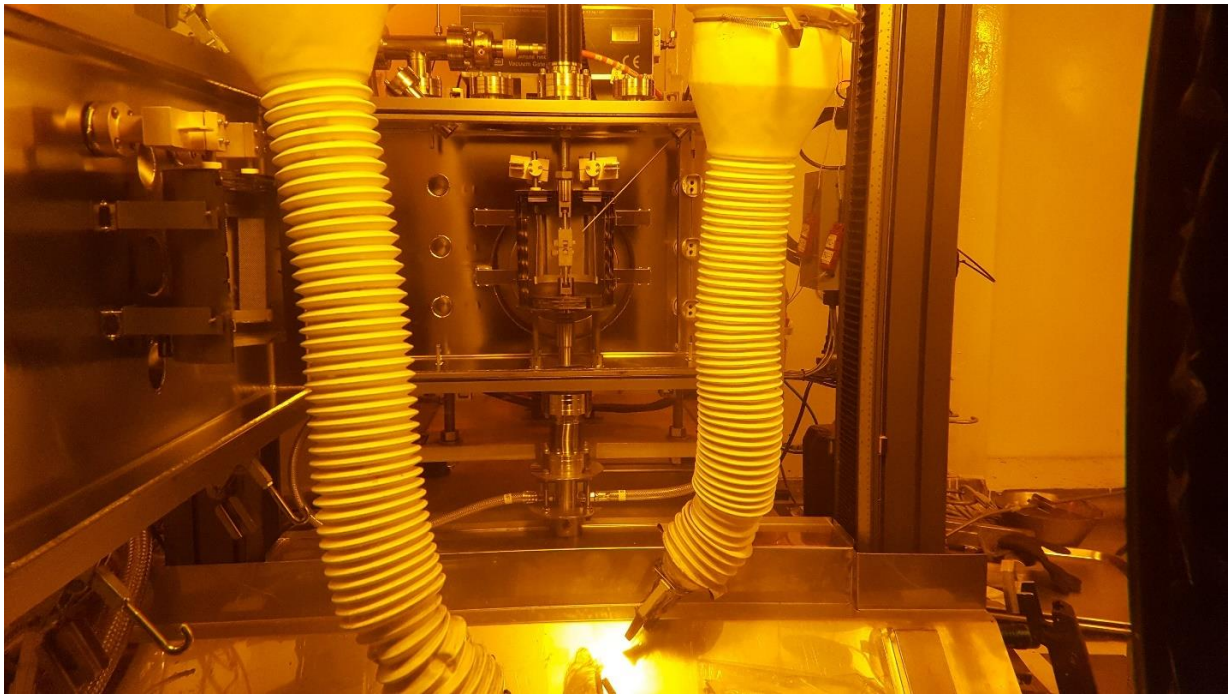

Figure 1. Instron mechanical frame in Cell #1 of IMET facility [3].

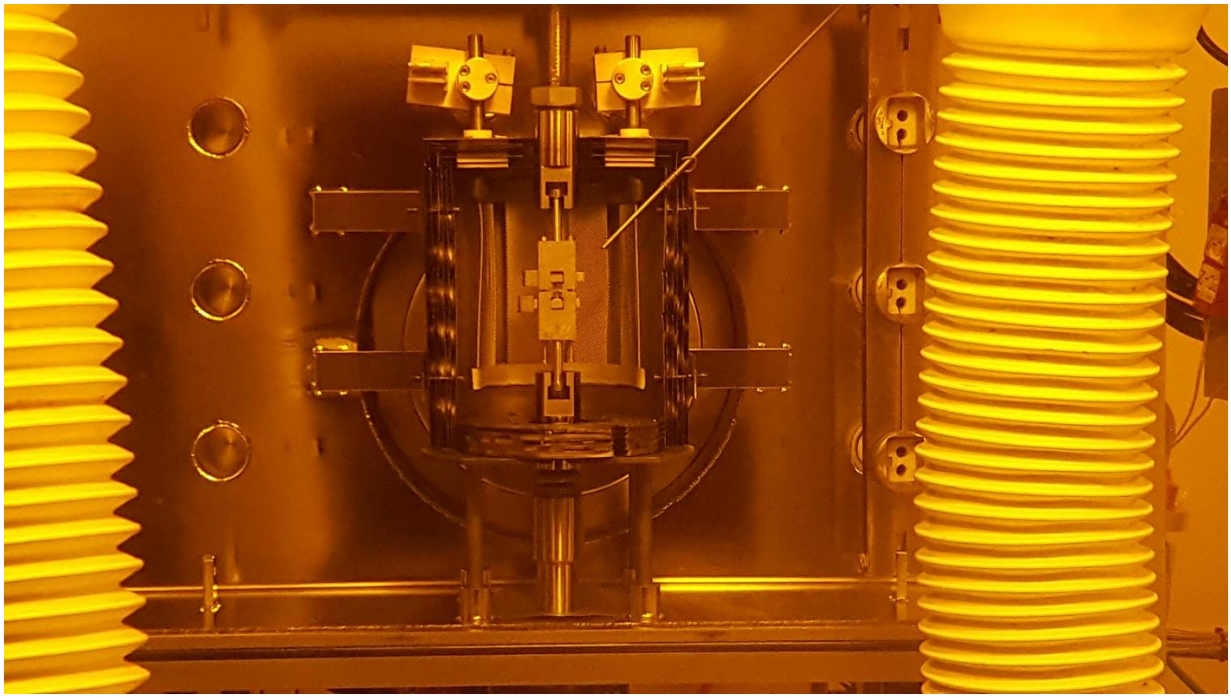

Figure 2. Close-up of tensile test fixture [3].

Table 1. Summary of tensile test matrix: round 3 and 4 data highlighted in green [3]

	Dose (dpa)			
	Unirradiated	**0.7**	**1.4**	**2.1**
Material	**Number of SSJ2 specimens**			
Al	3	3	3	3
Al+CNT[a]	3	3	3	3
Fe-16Cr-2Si	3	3	3	3
Fe-20Cr-2Si	3	3	3	3
Cu	3	2	3	3
Cu+CNT[a]	3	2	3	3
Single crystal Ni	1	3	3	3
Steel1	3	3	3	3
Steel1+OC[b]	3	3	3	3
Steel2	3	3	3	3
Steel2+OC[b]	3	3	3	3
Ni	3	3	3	3
Ni+CNT[a]	3	3	3	3
Totals	**37**	**37**	**39**	**39**

[a]CNT = carbon nano-tube
[b]OC = oxides/carbides

3. SELECTED TENSILE TEST RESULTS

The Cu- and Ni-base material specimens were selected to provide a general representation of the data collected. Figure 3 and Figure 4 show the raw data plots for the Cu and the Cu+CNT tensile materials, respectively. Figure 5, Figure 6, and Figure 7 show the raw data plots for the Ni, Ni+CNT, and single crystal Ni tensile materials, respectively. All figures of the same base material have the same *x*- and *y*-axis scales and color schemes for as-received, 0.7 dpa, 1.4 dpa, and 2.1 dpa dose ranges to allow for easier comparison of each alloy. The figures have not been corrected for machine compliance.

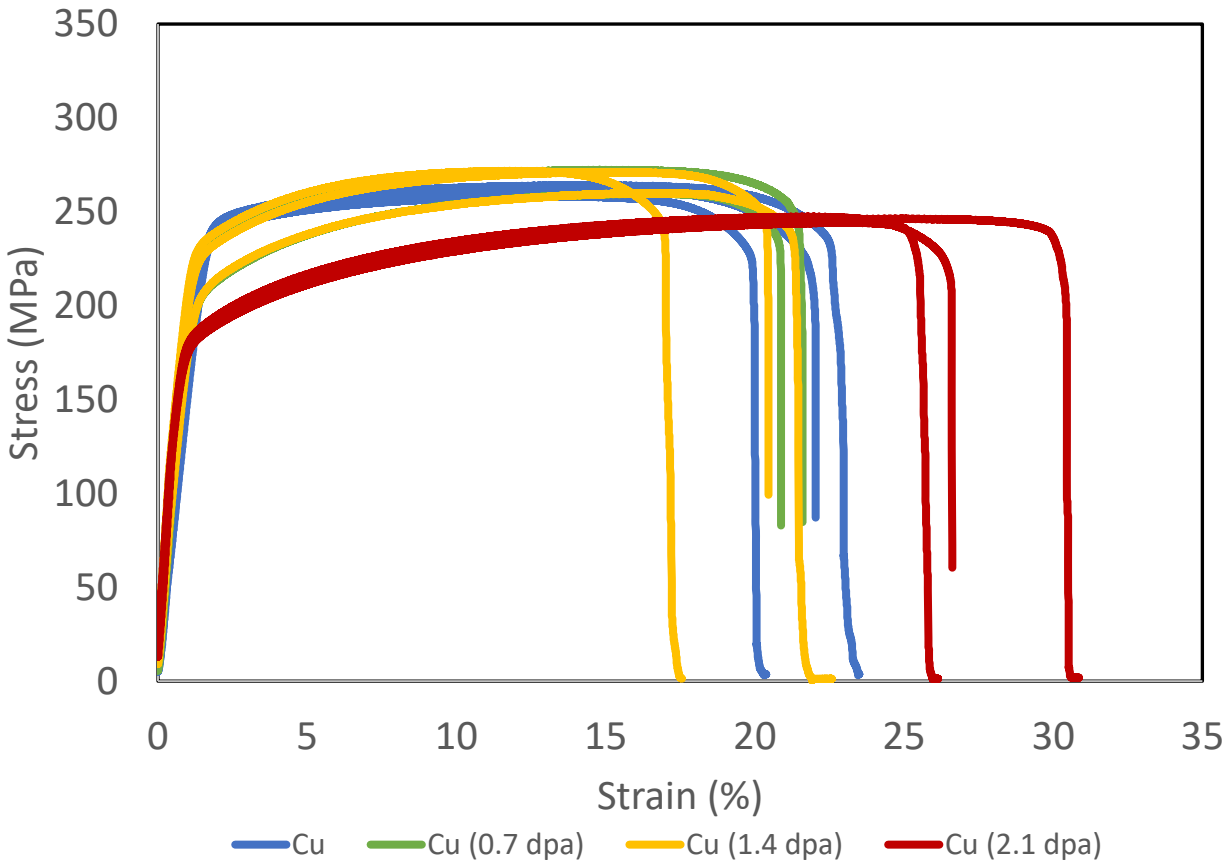

Figure 3. Raw data plot of stress (MPa) vs. strain (%) for the selected Cu tensile specimens, grouped by dose.

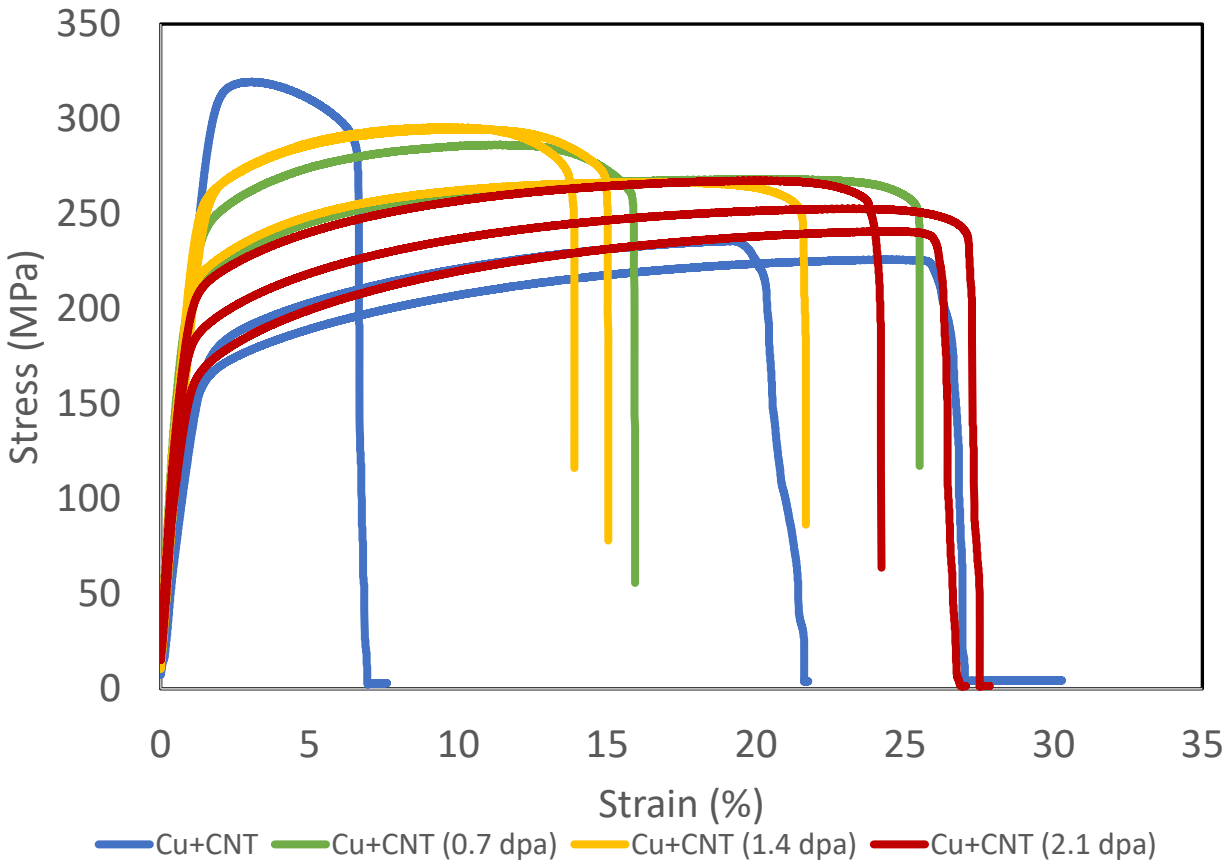

Figure 4. Raw data plot of stress (MPa) vs. strain (%) for the selected Cu+CNT tensile specimens, grouped by dose.

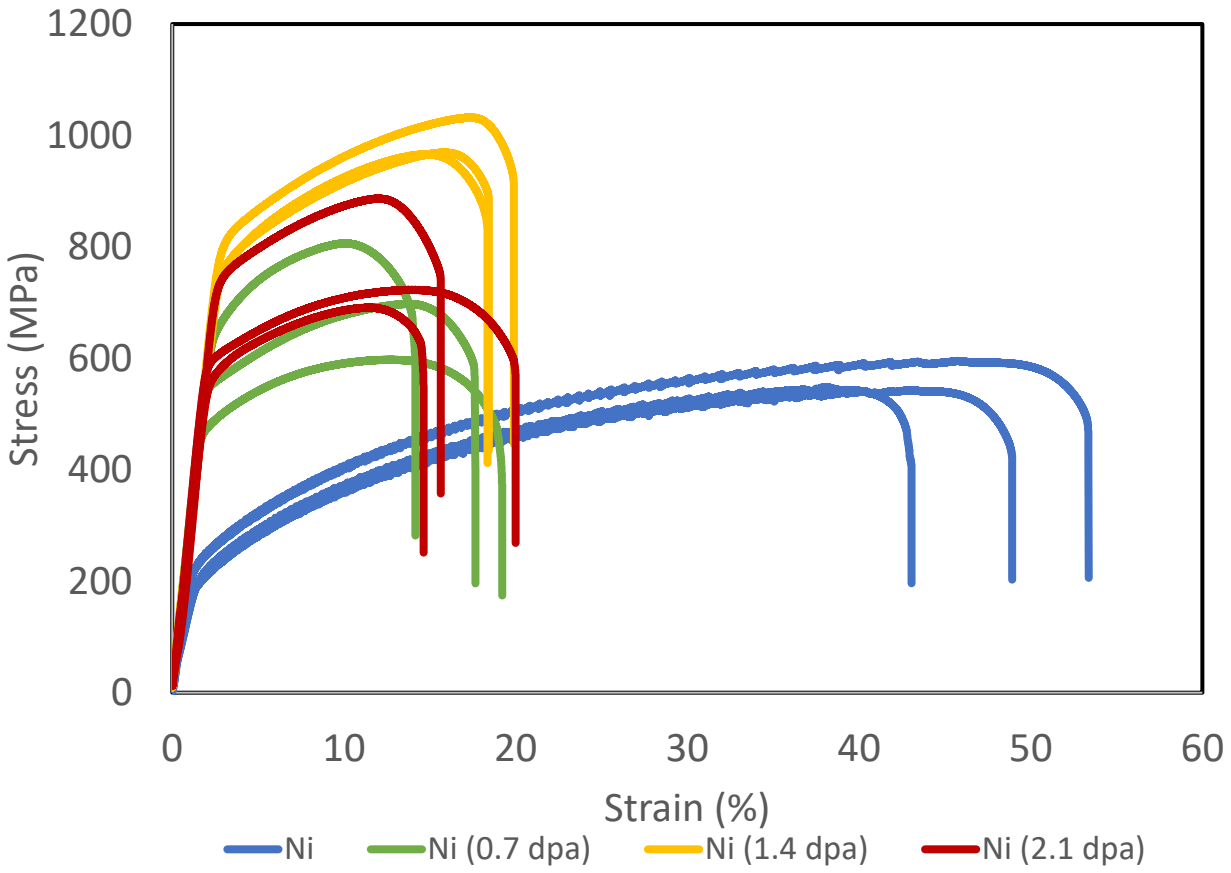

Figure 5. Raw data plot of stress (MPa) vs. strain (%) for the selected Ni tensile specimens, grouped by dose.

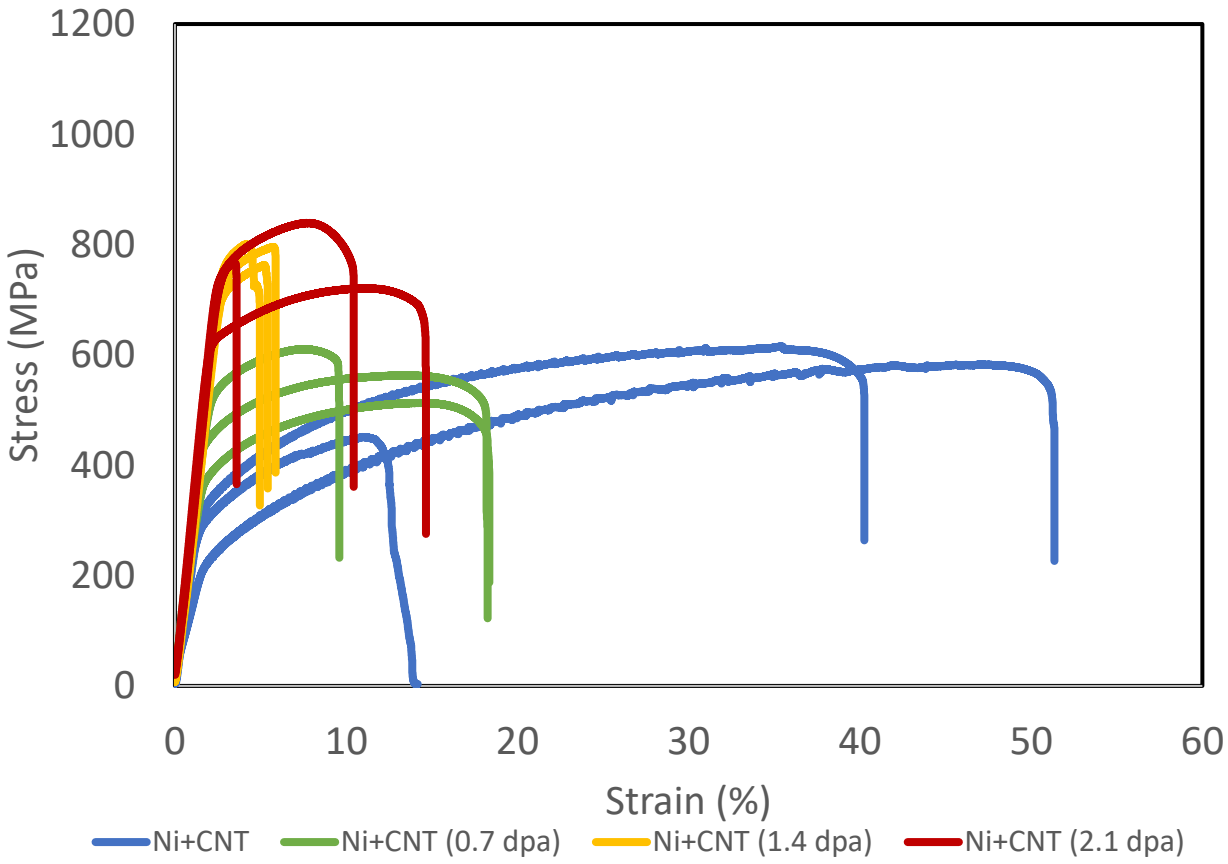

Figure 6. Raw data plot of stress (MPa) vs. strain (%) for the selected Ni+CNT tensile specimens, grouped by dose.

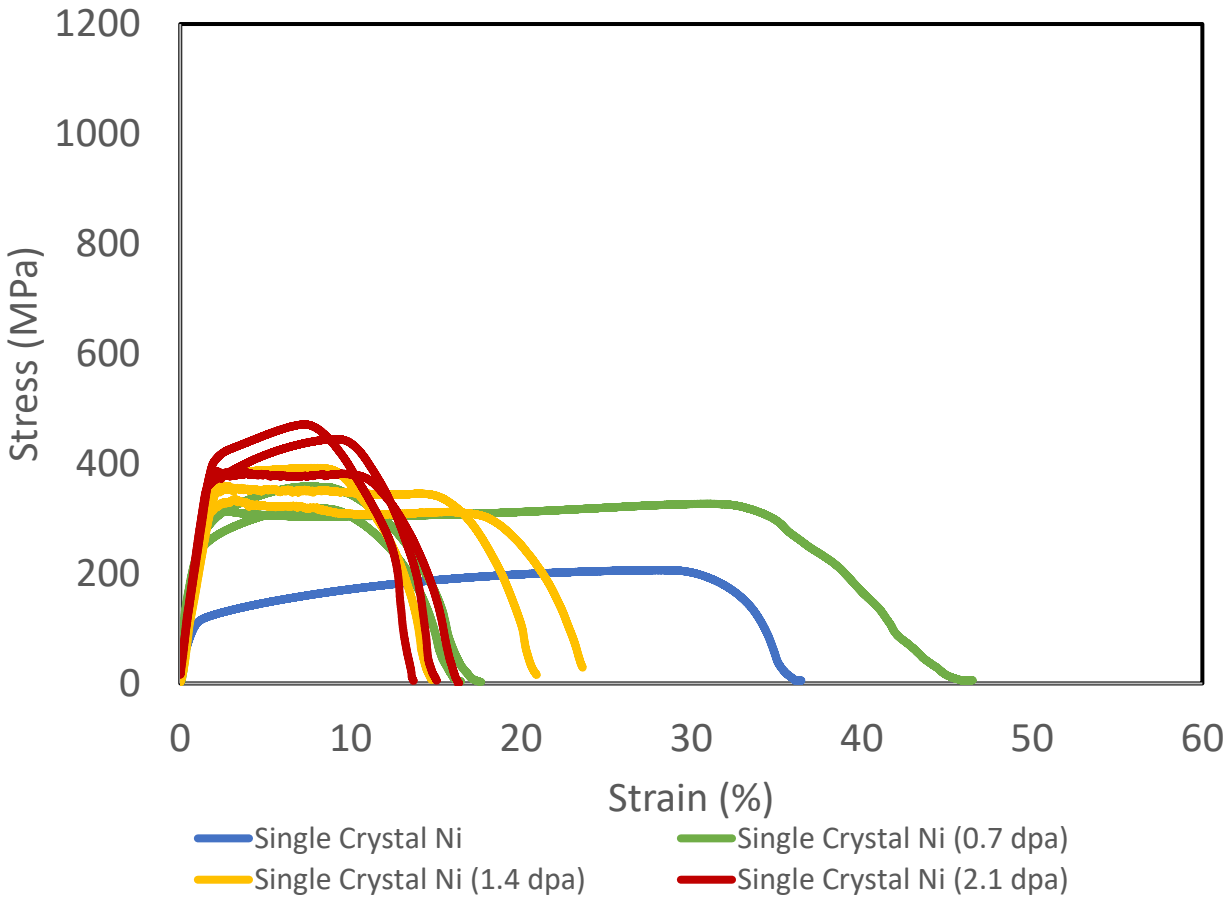

Figure 7. Raw data plot of stress (MPa) vs. strain (%) for the selected single crystal Ni tensile specimens, grouped by dose.

4. SUMMARY AND CONCLUSIONS

This report confirms the completion of postirradiation tensile testing of nanodispersion-strengthened materials at the IMET facility. All tension tests were performed at room temperature with a nominal strain rate of 0.018 mm/mm/min using shoulder-loading grip sets by following the standard testing procedure in ASTM E8/E8M. Round 3 (1.4 dpa) and round 4 (2.1 dpa) testing was completed, and data were provided to principal investigators. Sixteen samples have been selected for shipment to INL for additional characterization.

5. WORKS CITED

[1] S. Piela, R. Howard, A. Le Coq, K. Linton, J. Li, *Design and Assembly of Rabbit Capsules for Irradiation of Prototype Metal and Nanocomposite Specimens in the High Flux Isotope Reactor*, ORNL/SPR-2019/1306, Oak Ridge, TN, 2019.

[2] J. Werden, A. Le Coq, K. Linton, *Disassembly of Capsules After Irradiation of Prototype Metal and Nanocomposite Specimens in the High Flux Isotope Reactor*, ORNL/SPR-2021/1784, Oak Ridge, TN, 2021.

[3] J. Werden, B. Garrison, A. Le Coq, K. Linton, *Mechanical Testing of Prototype Metal and Nanocomposite Tensile Specimens after Irradiation*, ORNL/LTR-2021/2196, Oak Ridge, TN, 2021.

APPENDIX A. SPECIMEN LIST

Table A-1contains a more detailed list of every specimen that has been tested [3].

Table A-1. Detailed specimen list

Round	Capsule ID	Spec. ID	Material	dpa	Test
Rd 1	Unirradiated	M1A 17	Al	Unirradiated	Complete
Rd 1	Unirradiated	M1A 18	Al	Unirradiated	Complete
Rd 1	Unirradiated	M1A 19	Al	Unirradiated	Complete
Rd 1	Unirradiated	M2A 04	Al+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M2A 06	Al+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M2A 14	Al+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M3S 16	Fe-16Cr-2Si	Unirradiated	Complete
Rd 1	Unirradiated	M3S 17	Fe-16Cr-2Si	Unirradiated	Complete
Rd 1	Unirradiated	M3S 18	Fe-16Cr-2Si	Unirradiated	Complete
Rd 1	Unirradiated	M4S 16	Fe-20Cr-2Si	Unirradiated	Complete
Rd 1	Unirradiated	M4S 17	Fe-20Cr-2Si	Unirradiated	Complete
Rd 1	Unirradiated	M4S 18	Fe-20Cr-2Si	Unirradiated	Complete
Rd 1	Unirradiated	M5C 13	Cu	Unirradiated	Complete
Rd 1	Unirradiated	M5C 14	Cu	Unirradiated	Complete
Rd 1	Unirradiated	M5C 15	Cu	Unirradiated	Complete
Rd 1	Unirradiated	M6C 06	Cu+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M6C 11	Cu+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M6C 15	Cu+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M7N 16	single crystal Ni	Unirradiated	Complete
Rd 1	Unirradiated	M8S 08	Steel1	Unirradiated	Complete
Rd 1	Unirradiated	M8S 09	Steel1	Unirradiated	Complete
Rd 1	Unirradiated	M8S 11	Steel1	Unirradiated	Complete
Rd 1	Unirradiated	M9S01	Steel2	Unirradiated	Complete
Rd 1	Unirradiated	M9S02	Steel2	Unirradiated	Complete
Rd 1	Unirradiated	M9S03	Steel2	Unirradiated	Complete
Rd 1	Unirradiated	M10S 17	Steel1+OC	Unirradiated	Complete
Rd 1	Unirradiated	M10S 18	Steel1+OC	Unirradiated	Complete
Rd 1	Unirradiated	M10S 19	Steel1+OC	Unirradiated	Complete
Rd 1	Unirradiated	M11S 01	Steel2+OC	Unirradiated	Complete
Rd 1	Unirradiated	M11S 02	Steel2+OC	Unirradiated	Complete
Rd 1	Unirradiated	M11S 03	Steel2+OC	Unirradiated	Complete
Rd 1	Unirradiated	M12N 11	Ni	Unirradiated	Complete
Rd 1	Unirradiated	M12N 16	Ni	Unirradiated	Complete
Rd 1	Unirradiated	M12N 19	Ni	Unirradiated	Complete
Rd 1	Unirradiated	M13N 14	Ni+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M13N 16	Ni+CNT	Unirradiated	Complete
Rd 1	Unirradiated	M13N 17	Ni+CNT	Unirradiated	Complete

Table A-2. Detailed specimen list (continued)

Round	Capsule ID	Spec. ID	Material	dpa	Test
Rd 2	JULI01	M10S 01	Steel1+OC	0.7	Complete
Rd 2	JULI01	M10S 02	Steel1+OC	0.7	Complete
Rd 2	JULI01	M11S 08	Steel2+OC	0.7	Complete
Rd 2	JULI01	M11S 09	Steel2+OC	0.7	Complete
Rd 2	JULI01	M11S 10	Steel2+OC	0.7	Complete
Rd 2	JULI01	M12N 01	Ni	0.7	Complete
Rd 2	JULI01	M12N 12	Ni	0.7	Complete
Rd 2	JULI01	M13N 10	Ni+CNT	0.7	Complete
Rd 2	JULI01	M13N 11	Ni+CNT	0.7	Complete
Rd 2	JULI01	M13N 12	Ni+CNT	0.7	Complete
Rd 2	JULI01	M1A 01	Al	0.7	Complete
Rd 2	JULI01	M1A 02	Al	0.7	Complete
Rd 2	JULI01	M1A 03	Al	0.7	Complete
Rd 2	JULI01	M2A 07	Al+CNT	0.7	Complete
Rd 2	JULI01	M2A 08	Al+CNT	0.7	Complete
Rd 2	JULI01	M2A 09	Al+CNT	0.7	Complete
Rd 2	JULI01	M3S 01	Fe-16Cr-2Si	0.7	Complete
Rd 2	JULI01	M3S 02	Fe-16Cr-2Si	0.7	Complete
Rd 2	JULI01	M4S 06	Fe-20Cr-2Si	0.7	Complete
Rd 2	JULI01	M4S 07	Fe-20Cr-2Si	0.7	Complete
Rd 2	JULI01	M5C 01	Cu	0.7	Complete
Rd 2	JULI01	M5C 02	Cu	0.7	Complete
Rd 2	JULI01	M6C 04	Cu+CNT	0.7	Complete
Rd 2	JULI01	M6C 05	Cu+CNT	0.7	Complete
Rd 2	JULI01	M7N 01	single crystal Ni	0.7	Complete
Rd 2	JULI01	M7N 02	single crystal Ni	0.7	Complete
Rd 2	JULI01	M8S 01	Steel1	0.7	Complete
Rd 2	JULI01	M8S 02	Steel1	0.7	Complete
Rd 2	JULI01	M8S 03	Steel1	0.7	Complete
Rd 2	JULI01	M9S 08	Steel2	0.7	Complete
Rd 2	JULI01	M9S 09	Steel2	0.7	Complete
Rd 2	JULI02	M10S 03	Steel1+OC	0.7	Complete
Rd 2	JULI02	M12N 03	Ni	0.7	Complete
Rd 2	JULI02	M3S 03	Fe-16Cr-2Si	0.7	Complete
Rd 2	JULI02	M4S 08	Fe-20Cr-2Si	0.7	Complete
Rd 2	JULI02	M7N 03	single crystal Ni	0.7	Complete
Rd 2	JULI02	M9S 11	Steel2	0.7	Complete
Rd 3	JULI03	M10S 06	Steel1+OC	1.4	Complete
Rd 3	JULI03	M10S 07	Steel1+OC	1.4	Complete
Rd 3	JULI03	M11S 13	Steel2+OC	1.4	Complete
Rd 3	JULI03	M11S 14	Steel2+OC	1.4	Complete
Rd 3	JULI03	M11S 19	Steel2+OC	1.4	Complete

Table A-2. Detailed specimen list (continued)

Round	Capsule ID	Spec. ID	Material	dpa	Test
Rd 3	JULI03	M12N 06	Ni	1.4	Complete
Rd 3	JULI03	M12N 07	Ni	1.4	Complete
Rd 3	JULI03	M13N 03	Ni+CNT	1.4	Complete
Rd 3	JULI03	M1A 06	Al	1.4	Complete
Rd 3	JULI03	M1A 07	Al	1.4	Complete
Rd 3	JULI03	M1A 16	Al	1.4	Complete
Rd 3	JULI03	M2A 12	Al+CNT	1.4	Complete
Rd 3	JULI03	M2A 15	Al+CNT	1.4	Complete
Rd 3	JULI03	M2A13	Al+CNT	1.4	Complete
Rd 3	JULI03	M3S 06	Fe-16Cr-2Si	1.4	Complete
Rd 3	JULI03	M3S 07	Fe-16Cr-2Si	1.4	Complete
Rd 3	JULI03	M4S 11	Fe-20Cr-2Si	1.4	Complete
Rd 3	JULI03	M4S 12	Fe-20Cr-2Si	1.4	Complete
Rd 3	JULI03	M5C 05	Cu	1.4	Complete
Rd 3	JULI03	M5C 06	Cu	1.4	Complete
Rd 3	JULI03	M5C 07	Cu	1.4	Complete
Rd 3	JULI03	M6C 03	Cu+CNT	1.4	Complete
Rd 3	JULI03	M6C 07	Cu+CNT	1.4	Complete
Rd 3	JULI03	M6C 08	Cu+CNT	1.4	Complete
Rd 3	JULI03	M8S 06	Steel1	1.4	Complete
Rd 3	JULI03	M8S 07	Steel1	1.4	Complete
Rd 3	JULI03	M8S 10	Steel1	1.4	Complete
Rd 3	JULI03	M9S13	Steel2	1.4	Complete
Rd 3	JULI03	M9S14	Steel2	1.4	Complete
Rd 3	JULI04	M10S 16	Steel1+OC	1.4	Complete
Rd 3	JULI04	M12N 08	Ni	1.4	Complete
Rd 3	JULI04	M13N 13	Ni+CNT	1.4	Complete
Rd 3	JULI04	M13N 20	Ni+CNT	1.4	Complete
Rd 3	JULI04	M3S 08	Fe-16Cr-2Si	1.4	Complete
Rd 3	JULI04	M4S 13	Fe-20Cr-2Si	1.4	Complete
Rd 3	JULI04	M7N 08	single crystal Ni	1.4	Complete
Rd 3	JULI04	M7N 09	single crystal Ni	1.4	Complete
Rd 3	JULI04	M7N 10	single crystal Ni	1.4	Complete
Rd 3	JULI04	M9S15	Steel2	1.4	Complete
Rd 4	JULI05	M10S 11	Steel1+OC	2.1	Complete
Rd 4	JULI05	M10S 12	Steel1+OC	2.1	Complete
Rd 4	JULI05	M11S 04	Steel2+OC	2.1	Complete
Rd 4	JULI05	M11S 05	Steel2+OC	2.1	Complete
Rd 4	JULI05	M12N 17	Ni	2.1	Complete
Rd 4	JULI05	M12N 18	Ni	2.1	Complete
Rd 4	JULI05	M13N 07	Ni+CNT	2.1	Complete
Rd 4	JULI05	M1A 11	Al	2.1	Complete

Table A-2. Detailed specimen list (continued)

Round	Capsule ID	Spec. ID	Material	dpa	Test
Rd 4	JULI05	M1A 12	Al	2.1	Complete
Rd 4	JULI05	M1A 13	Al	2.1	Complete
Rd 4	JULI05	M2A 01	Al+CNT	2.1	Complete
Rd 4	JULI05	M2A 02	Al+CNT	2.1	Complete
Rd 4	JULI05	M2A 03	Al+CNT	2.1	Complete
Rd 4	JULI05	M3S 11	Fe-16Cr-2Si	2.1	Complete
Rd 4	JULI05	M3S 12	Fe-16Cr-2Si	2.1	Complete
Rd 4	JULI05	M4S 01	Fe-20Cr-2Si	2.1	Complete
Rd 4	JULI05	M4S 02	Fe-20Cr-2Si	2.1	Complete
Rd 4	JULI05	M5C 09	Cu	2.1	Complete
Rd 4	JULI05	M5C 10	Cu	2.1	Complete
Rd 4	JULI05	M5C 11	Cu	2.1	Complete
Rd 4	JULI05	M6C 10	Cu+CNT	2.1	Complete
Rd 4	JULI05	M6C 12	Cu+CNT	2.1	Complete
Rd 4	JULI05	M6C 13	Cu+CNT	2.1	Complete
Rd 4	JULI05	M7N 11	single crystal Ni	2.1	Complete
Rd 4	JULI05	M7N 12	single crystal Ni	2.1	Complete
Rd 4	JULI05	M8S 15	Steel1	2.1	Complete
Rd 4	JULI05	M8S 16	Steel1	2.1	Complete
Rd 4	JULI05	M8S 17	Steel1	2.1	Complete
Rd 4	JULI05	M9S18	Steel2	2.1	Complete
Rd 4	JULI05	M9S19	Steel2	2.1	Complete
Rd 4	JULI06	M10S 13	Steel1+OC	2.1	Complete
Rd 4	JULI06	M11S 06	Steel2+OC	2.1	Complete
Rd 4	JULI06	M12N 13	Ni	2.1	Complete
Rd 4	JULI06	M13N 08	Ni+CNT	2.1	Complete
Rd 4	JULI06	M13N 09	Ni+CNT	2.1	Complete
Rd 4	JULI06	M3S 13	Fe-16Cr-2Si	2.1	Complete
Rd 4	JULI06	M4S 03	Fe-20Cr-2Si	2.1	Complete
Rd 4	JULI06	M7N 13	single crystal Ni	2.1	Complete
Rd 4	JULI06	M9S20	Steel2	2.1	Complete
Reserve	JULI01	M5C 03	Cu	0.7	N/A
Reserve	JULI01	M6C 02	Cu+CNT	0.7	N/A
Reserve	JULI02	M10S 04	Steel1+OC	0.7	N/A
Reserve	JULI02	M10S 05	Steel1+OC	0.7	N/A
Reserve	JULI02	M11S 11	Steel2+OC	0.7	N/A
Reserve	JULI02	M11S 12	Steel2+OC	0.7	N/A
Reserve	JULI02	M12N 04	Ni	0.7	N/A
Reserve	JULI02	M12N 05	Ni	0.7	N/A
Reserve	JULI02	M13N 04	Ni+CNT	0.7	N/A
Reserve	JULI02	M13N 05	Ni+CNT	0.7	N/A
Reserve	JULI02	M1A 04	Al	0.7	N/A

Table A-2. Detailed specimen list (continued)

Round	Capsule ID	Spec. ID	Material	dpa	Test
Reserve	JULI02	M1A 05	Al	0.7	N/A
Reserve	JULI02	M2A 10	Al+CNT	0.7	N/A
Reserve	JULI02	M2A 11	Al+CNT	0.7	N/A
Reserve	JULI02	M3S 04	Fe-16Cr-2Si	0.7	N/A
Reserve	JULI02	M3S 05	Fe-16Cr-2Si	0.7	N/A
Reserve	JULI02	M4S 09	Fe-20Cr-2Si	0.7	N/A
Reserve	JULI02	M4S 10	Fe-20Cr-2Si	0.7	N/A
Reserve	JULI02	M5C 04	Cu	0.7	N/A
Reserve	JULI02	M6C 01	Cu+CNT	0.7	N/A
Reserve	JULI02	M7N 04	single crystal Ni	0.7	N/A
Reserve	JULI02	M7N 05	single crystal Ni	0.7	N/A
Reserve	JULI02	M8S 04	Steel1	0.7	N/A
Reserve	JULI02	M8S 05	Steel1	0.7	N/A
Reserve	JULI02	M9S10	Steel2	0.7	N/A
Reserve	JULI02	M9S12	Steel2	0.7	N/A
Reserve	JULI03	M13N 01	Ni+CNT	1.4	N/A
Reserve	JULI03	M13N 02	Ni+CNT	1.4	N/A
Reserve	JULI03	M7N 06	single crystal Ni	1.4	N/A
Reserve	JULI03	M7N 07	single crystal Ni	1.4	N/A
Reserve	JULI04	M10S 09	Steel1+OC	1.4	N/A
Reserve	JULI04	M10S 10	Steel1+OC	1.4	N/A
Reserve	JULI04	M11S 16	Steel2+OC	1.4	N/A
Reserve	JULI04	M11S 17	Steel2+OC	1.4	N/A
Reserve	JULI04	M12N 09	Ni	1.4	N/A
Reserve	JULI04	M12N 10	Ni	1.4	N/A
Reserve	JULI04	M1A 09	Al	1.4	N/A
Reserve	JULI04	M1A 10	Al	1.4	N/A
Reserve	JULI04	M2A 16	Al+CNT	1.4	N/A
Reserve	JULI04	M2A 17	Al+CNT	1.4	N/A
Reserve	JULI04	M3S 09	Fe-16Cr-2Si	1.4	N/A
Reserve	JULI04	M3S 10	Fe-16Cr-2Si	1.4	N/A
Reserve	JULI04	M4S 14	Fe-20Cr-2Si	1.4	N/A
Reserve	JULI04	M4S 15	Fe-20Cr-2Si	1.4	N/A
Reserve	JULI04	M5C 08	Cu	1.4	N/A
Reserve	JULI04	M6C 09	Cu+CNT	1.4	N/A
Reserve	JULI04	M8S 12	Steel1	1.4	N/A
Reserve	JULI04	M8S13	Steel1	1.4	N/A
Reserve	JULI04	M9S06	Steel2	1.4	N/A
Reserve	JULI04	M9S17	Steel2	1.4	N/A
Reserve	JULI05	M11S 18	Steel2+OC	2.1	N/A
Reserve	JULI05	M13N 06	Ni+CNT	2.1	N/A
Reserve	JULI05	M13N 15	Ni+CNT	2.1	N/A

Table A-2. Detailed specimen list (continued)

Round	Capsule ID	Spec. ID	Material	dpa	Test
Reserve	JULI06	M10S 14	Steel1+OC	2.1	N/A
Reserve	JULI06	M10S 15	Steel1+OC	2.1	N/A
Reserve	JULI06	M11S 07	Steel2+OC	2.1	N/A
Reserve	JULI06	M12N 14	Ni	2.1	N/A
Reserve	JULI06	M12N 15	Ni	2.1	N/A
Reserve	JULI06	M1A 14	Al	2.1	N/A
Reserve	JULI06	M1A 15	Al	2.1	N/A
Reserve	JULI06	M2A 05	Al+CNT	2.1	N/A
Reserve	JULI06	M2A 19	Al+CNT	2.1	N/A
Reserve	JULI06	M3S 14	Fe-16Cr-2Si	2.1	N/A
Reserve	JULI06	M3S 15	Fe-16Cr-2Si	2.1	N/A
Reserve	JULI06	M4S 04	Fe-20Cr-2Si	2.1	N/A
Reserve	JULI06	M4S 05	Fe-20Cr-2Si	2.1	N/A
Reserve	JULI06	M5C 12	Cu	2.1	N/A
Reserve	JULI06	M6C 14	Cu+CNT	2.1	N/A
Reserve	JULI06	M7N 14	single crystal Ni	2.1	N/A
Reserve	JULI06	M7N 15	single crystal Ni	2.1	N/A
Reserve	JULI06	M8S 19	Steel1	2.1	N/A
Reserve	JULI06	M8S 20	Steel1	2.1	N/A
Reserve	JULI06	M9S21	Steel2	2.1	N/A
Reserve	JULI06	M9S22	Steel2	2.1	N/A

APPENDIX B. SAMPLES SELECTED FOR SHIPMENT

Table B-1 contains a list of specimens selected for shipment to INL for microstructural characterization.

Table B-1. Samples selected for INL shipment

ID#	Mass (grams)	Broken	Material	dpa	HFIR rabbit ID
M8S 08	0.16	Yes	Steel1	As received	
M8S 01	0.167	Yes	Steel1	0.7	JULI01
M8S 07	0.1633	Yes	Steel1	1.4	JULI03
M8S 17	0.1701	Yes	Steel1	2.1	JULI05
M10S 19	0.1736	Yes	Steel1 + OC	As received	
M10S 01	0.1674	Yes	Steel1 + OC	0.7	JULI01
M10S 07	0.1703	Yes	Steel1 + OC	1.4	JULI03
M10S 11	0.1748	Yes	Steel1 + OC	2.1	JULI05
M9S 01	0.1639	Yes	Steel2	As received	
M9S 09	0.1643	Yes	Steel2	0.7	JULI01
M9S 13	0.1738	Yes	Steel2	1.4	JULI03
M9S 18	0.1719	Yes	Steel2	2.1	JULI05
M11S 03	0.1742	Yes	Steel2 + OC	As received	
M11S 10	0.1611	Yes	Steel2 + OC	0.7	JULI01
M11S 13	0.1776	Yes	Steel2 + OC	1.4	JULI03
M11S 05	0.1744	Yes	Steel2 + OC	2.1	JULI05