APPENDIX

Strain Hardening Behavior of Heat-Treated Austenitic Manganese

Raw Data and Sample Calculations

Table A1. Stress-strain data for unalloyed sample poured at 1410°C. Data set has been truncated by taking every 75th data point until UTS.

Modulus of Elasticity : 101623.05 MPa
Offset Yield Stress : 222.00 MPa

data point, *i*	*e* [-]	*s* [MPa]	ε_t [-]	σ [MPa]	ε_p [-]	*n** [-]	$\frac{d\sigma}{d\varepsilon}$ [MPa]
1	0.00067	73.83	0.00067	73.88	-	-	-
76	0.00104	112.42	0.00104	112.54	-	-	-
151	0.00142	149.76	0.00142	149.97	-	-	-
226	0.00179	186.07	0.00179	186.40	-	-	-
301	0.00217	220.29	0.00217	220.77	-	-	-
376	0.00254	252.30	0.00254	252.95	0.00005	-	-
451	0.00292	281.49	0.00291	282.31	0.00014	0.12158	265424.36
526	0.00329	306.90	0.00329	307.91	0.00026	0.14116	172473.48
601	0.00367	328.89	0.00366	330.10	0.00041	0.14395	115443.12
676	0.00404	346.90	0.00404	348.30	0.00061	0.13558	78232.03
751	0.00442	361.52	0.00441	363.12	0.00084	0.12771	55929.25
826	0.00479	373.45	0.00478	375.24	0.00109	0.11926	41317.15
901	0.00517	383.06	0.00516	385.04	0.00137	0.11203	31783.07
976	0.00554	391.14	0.00553	393.30	0.00166	0.10443	24870.51
1051	0.00592	397.59	0.00590	399.94	0.00197	0.09431	19264.66
1126	0.00629	402.84	0.00627	405.37	0.00228	0.07334	13001.49
1201	0.00667	405.83	0.00665	408.53	0.00263	0.01726	2665.82

Sample calculation for ε_p using data from Table A1:

$$\varepsilon_{p,451} = \ln(1 + e_{451}) - \frac{s_{451}(1 + e_{451})}{E} = \ln(1 + 0.00292) - \frac{281.49(1 + 0.00292)}{101623.05}$$
$$= 0.00014$$

Sample calculation for n^* using data from Table A1:

$$n^*_{976} = \frac{\ln(\sigma_{1051}/\sigma_{901})}{\ln(\varepsilon_{1051}/\varepsilon_{901})} = \frac{\ln(399.94/385.04)}{\ln(0.00197/0.00137)} = 0.10443$$

Sample calculation for $\frac{d\sigma}{d\varepsilon}$ using data from Table A1:

$$\frac{d\sigma}{d\varepsilon} \approx \frac{\sigma_{751} - \sigma_{601}}{\varepsilon_{751} - \varepsilon_{601}} = \frac{363.12 - 330.10}{0.00084 - 0.00041} = 115443.12$$

Table A2. Stress-strain data for unalloyed sample poured at 1450°C. Data set has been truncated by taking every 75th data point until UTS.

Modulus of Elasticity	:	151180.52 MPa
Offset Yield Stress	:	232.00 MPa

data point, i	e [-]	s [MPa]	ε_t [-]	σ [MPa]	ε_p [-]	n^* [-]	$\frac{d\sigma}{d\varepsilon}$ [MPa]
1	0.00020	32.36	0.00020	32.37	-	-	-
76	0.00058	93.18	0.00058	93.23	-	-	-
151	0.00095	150.94	0.00095	151.09	-	-	-
226	0.00132	202.54	0.00132	202.81	-	-	-
301	0.00170	244.31	0.00170	244.73	0.00008	-	-
376	0.00207	276.30	0.00207	276.87	0.00024	0.11825	150747.7553
451	0.00245	300.50	0.00245	301.23	0.00045	0.13481	93168.86
526	0.00282	319.09	0.00282	319.99	0.00070	0.13850	64566.80
601	0.00320	334.00	0.00319	335.07	0.00098	0.13671	47489.14
676	0.00357	345.77	0.00357	347.00	0.00127	0.12887	35484.02
751	0.00395	355.14	0.00394	356.55	0.00158	0.11638	26363.48
826	0.00432	362.21	0.00431	363.77	0.00191	0.10200	19547.84
901	0.00470	367.75	0.00469	369.48	0.00224	0.09013	14902.90
976	0.00507	372.01	0.00506	373.90	0.00259	0.05815	8390.54
1051	0.00545	373.37	0.00543	375.41	0.00295	0.01466	1866.88

Table A3. Stress-strain data for unalloyed sample poured at 1370°C. Data set has been truncated by taking every 75th data point until UTS.

Modulus of Elasticity	:	95100.27 MPa
Offset Yield Stress	:	219.00 MPa

data point, i	e [-]	s [MPa]	ε_t [-]	σ [MPa]	ε_p [-]	n^* [-]	$\frac{d\sigma}{d\varepsilon}$ [MPa]
1	0.00025	26.53	0.00025	26.54	-	-	-
76	0.00062	64.05	0.00062	64.09	-	-	-
151	0.00100	100.00	0.00100	100.10	-	-	-
226	0.00137	135.29	0.00137	135.48	-	-	-
301	0.00175	169.69	0.00174	169.98	-	-	-
376	0.00212	202.60	0.00212	203.03	-	-	-
451	0.00250	232.94	0.00249	233.52	0.00004	-	-
526	0.00287	260.49	0.00287	261.24	0.00012	0.10407	239465.55
601	0.00325	283.52	0.00324	284.44	0.00025	0.11676	135523.71
676	0.00362	301.91	0.00361	303.01	0.00043	0.11447	82070.87
751	0.00400	316.09	0.00399	317.35	0.00065	0.11074	54989.80
826	0.00437	327.60	0.00436	329.03	0.00090	0.11123	41151.13
901	0.00475	337.20	0.00474	338.80	0.00117	0.11331	33126.17
976	0.00512	345.60	0.00511	347.37	0.00146	0.11722	28212.50
1051	0.00550	353.10	0.00548	355.04	0.00175	0.11718	23918.84
1126	0.00587	359.52	0.00585	361.63	0.00205	0.11762	20852.35
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1201	0.00625	365.50	0.00623	367.79	0.00236	0.11448	17878.04
1276	0.00662	370.40	0.00660	372.85	0.00268	0.09816	13674.91
1351	0.00700	374.08	0.00697	376.70	0.00301	0.07581	9487.69
1426	0.00737	376.50	0.00734	379.27	0.00336	0.06065	6871.39
1501	0.00775	378.53	0.00772	381.47	0.00371	0.06394	6605.87
1576	0.00812	380.78	0.00809	383.87	0.00405	0.06455	6122.08
1651	0.00850	382.50	0.00846	385.75	0.00440	0.06597	5794.99
1726	0.00887	384.52	0.00883	387.93	0.00475	0.06234	5088.02
1801	0.00925	385.77	0.00920	389.34	0.00511	0.02131	1620.42

Table A4. Stress-strain data for sample alloyed with 0.6wt% Ce. Data set has been truncated by taking every 75th data point until UTS.

Modulus of Elasticity	:	97639.52 MPa
Offset Yield Stress	:	252.50 MPa

data point, i	e [-]	s [MPa]	ε_t [-]	σ [MPa]	ε_p [-]	n^* [-]	$\frac{d\sigma}{d\varepsilon}$ [MPa]
1	0.00021	24.57	0.00021	24.57	-	-	-
76	0.00059	62.37	0.00059	62.40	-	-	-
151	0.00096	99.70	0.00096	99.79	-	-	-
226	0.00134	136.17	0.00134	136.35	-	-	-
301	0.00171	172.05	0.00171	172.34	-	-	-
376	0.00209	207.11	0.00208	207.55	-	-	-
451	0.00246	241.28	0.00246	241.88	-	-	-
526	0.00284	273.35	0.00283	274.12	0.00002	-	-
601	0.00321	303.00	0.00321	303.97	0.00009	0.08947	324179.54
676	0.00359	329.06	0.00358	330.24	0.00020	0.11565	199759.10
751	0.00396	351.59	0.00395	352.98	0.00034	0.12197	128153.87
826	0.00434	370.03	0.00433	371.64	0.00052	0.11505	82662.91
901	0.00471	384.61	0.00470	386.42	0.00074	0.10706	56258.46
976	0.00509	396.27	0.00507	398.28	0.00099	0.10538	42765.18
1051	0.00546	406.39	0.00545	408.61	0.00126	0.10975	35902.74
1126	0.00584	415.43	0.00582	417.85	0.00154	0.11271	30790.12
1201	0.00621	423.43	0.00619	426.06	0.00183	0.11808	27712.92
1276	0.00659	431.10	0.00656	433.94	0.00212	0.12031	24687.81
1351	0.00696	437.70	0.00694	440.75	0.00242	0.11795	21535.16
1426	0.00734	443.83	0.00731	447.09	0.00273	0.10802	17683.75
1501	0.00771	448.43	0.00768	451.89	0.00305	0.08559	12670.80
1576	0.00809	451.78	0.00805	455.44	0.00339	0.07103	9561.09
1651	0.00846	454.52	0.00843	458.37	0.00373	0.06493	7991.89
1726	0.00884	456.89	0.00880	460.93	0.00408	0.06807	7718.24
1801	0.00921	459.46	0.00917	463.69	0.00442	0.06314	6624.38
1876	0.00959	461.12	0.00954	465.54	0.00477	0.05003	4886.25

Table A5. Stress-strain data for sample alloyed with 0.1wt% Ti. Data set has been truncated by taking every 75th data point until UTS.

Modulus of Elasticity	:	94669.73 MPa
Offset Yield Stress	:	253.00 MPa

data point, i	e [-]	s [MPa]	ε_t [-]	σ [MPa]	ε_p [-]	n^* [-]	$\frac{d\sigma}{d\varepsilon}$ [MPa]
1	0.00020	19.76	0.00020	19.76	-	-	-
76	0.00057	56.79	0.00057	56.82	-	-	-
151	0.00095	94.58	0.00095	94.67	-	-	-
226	0.00132	132.08	0.00132	132.25	-	-	-
301	0.00170	168.80	0.00170	169.09	-	-	-
376	0.00207	203.97	0.00207	204.40	-	-	-
451	0.00245	236.44	0.00245	237.02	-	-	-
526	0.00282	266.07	0.00282	266.82	0.00000	-	-
601	0.00320	292.27	0.00319	293.20	0.00010	0.03366	217376.92
676	0.00357	314.98	0.00357	316.11	0.00023	0.09688	144145.07
751	0.00395	334.57	0.00394	335.89	0.00039	0.11299	98634.65
826	0.00432	350.68	0.00431	352.20	0.00059	0.10836	64622.64
901	0.00470	362.87	0.00469	364.58	0.00084	0.09521	41824.33
976	0.00507	371.96	0.00506	373.85	0.00111	0.07796	26307.28
1051	0.00545	377.88	0.00543	379.94	0.00142	0.04752	12691.91
1126	0.00582	379.99	0.00581	382.20	0.00177	0.00741	1599.39