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HNS PRESSABILITY STUDY

J. A. Crutchmer

DEVELOPMENT DIVISION

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FINAL REPORT

For
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Albuquerque, New Mexico

MASTER

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ABSTRACT

A pressability study was conducted using twenty-two HNS samples provided by Sandia Laboratories, Albuquerque, New Mexico. Two additional samples of HNS I, formulated at Pantex, were evaluated with the Sandia samples. Pellet density was determined as a function of pressure for each of the samples. Additional pellets were pressed—using a mechanical stop—to determine pellet rebound.

The Sandia samples were analyzed by liquid chromatography, and were X-rayed for high density inclusions.

DISCUSSION

A pressability study was completed for twenty-two HNS samples provided by Sandia Laboratory, Albuquerque, New Mexico, and two Pantex samples of HNS I.

Liquid chromatography analysis was conducted on the Sandia samples. The only detectable impurity was dipicrylethane. The analyses of the samples are given in Table I. Radiography results of high density inclusions are summarized in Table II.

PRESSING TECHNIQUE

Pellets were pressed at seven different pressure levels ranging from 7 to 276 MPa using a 7.6 mm diameter punch and die set. All pellets were pressed to $L/D = 1$. Fig. 1 shows a simple schematic of the punch and die set. This particular punch and die has provisions for vacuum and heating, but these were not used for this study.

The pellets were pressed using a dead weight press with a lever-arm advantage of approximately 10:1. This allowed accurate force control at each pressure level. Any type of press could be used for a study of this nature as long as it met the force requirements and was accurately repeatable.

The first pellet at each pressure level required an estimate of the expected pellet density. Powder weight was then adjusted to give a pellet height within $\pm 10\%$ of the diameter. Three pellets were pressed at each pressure level for each of the samples. Dwell time was 30 seconds. All pellets were weighed and gaged immediately after pressing. They were gaged again at five minutes and one hour after pressing. No significant growth occurred during this interval. Pellet densities as functions of pressure are shown in Table III and Figs. 2 through 25.

After all pellets were pressed at the various pressure levels, additional pellets were pressed to these resultant densities to determine pellet

rebound. This was accomplished by pressing to stops of various shim thicknesses. Pellet rebound as a function of density is given in Table IV and Figs. 2 through 25.

Only eight of the twenty-four samples produced physically stable pellets at 7 MPa (see Tables III and IV and the corresponding figures). These pellets were very soft and difficult to handle. Pellets pressed at 7 MPa from the remaining samples would not hold together well enough to obtain accurate measurements to calculate the densities.

All samples produced excellent pellets from 110 to 276 MPa. Most of the pellets pressed at 21 and 55 MPa were somewhat soft, which was expected. However, these pellets were solid enough to obtain accurate dimensions. The density gradient through the pellets was quite obvious throughout the pressure range, even at 276 MPa. The anvil end of the pellets was somewhat softer and a slightly different color than the punch end. No attempt was made to measure the density gradient.

Sample 1627-3, HNS II, seemed to be much more abrasive than the other samples. This powder left a dark deposit on the anvil and punch. Emery cloth was required to remove the deposit.

Fig. 26 is a plot of pellet density versus bulk density for samples 1627-2 through 1627-19, excluding sample 1627-5 which is HNS II Superfine. The pellet densities from this sample were considerably lower than those from other samples with comparable bulk densities. Curves representing the different pressure levels were added to Fig. 26. The bulk density of each sample is shown on its corresponding pressure-density curve (Figs. 2 through 25).

CONCLUSIONS

The slopes of the curves for all of the samples, except 1627-5, fell into two distinct groups according to type of HNS. The slopes for the HNS I ranged from 0.162 to 0.190 while those for HNS II ranged from 0.076 to 0.158. Sample 1627-5, which was HNS II Superfine had a slope of 0.195. This material pressed more like the Type I material which would be expected from its smaller particle size.

The pellet density versus bulk density plot, Fig. 26, shows a good deal of scatter, particularly for the lower bulk density materials. This curve indicates that those materials with a bulk density higher than approximately 0.35 Mg/m^3 would be desirable from a pressability standpoint.

Table I. Liquid Chromatograph Results of HNS Samples

<u>Sample No.</u>	<u>HNS Type</u>	<u>Percent DP^a</u>
1627-2	I	3.5 ± 0.04
1627-3	II	0.5 ± 0.12
1627-4	II	1.2 ± 0.02
1627-5	II Superfine	0.5
1627-6	I	2.5 ± 0.12
1627-7	II	2.0 ± 0.02
1627-8	I	2.8 ± 0.13
1627-9	II	2.0 ± 0.07
1627-10	I	0.8 ± 0.03
1627-11	II	2.7 ± 0.04
1627-12	I	1.1 ± 0.10
1627-13	II-B1627-14	0.6 ± 0.07
1627-14	I	0.8 ± 0.06
1627-15	II	0.5
1627-16	I	0.6 ± 0.04
1627-17	II	1.2 ± 0.05
1627-18	I	3.5 ± 0.04
1623-19	II	0.5
22 1b Lot	II	0.61 ± 0.08
20A	II (Coarse)	1.58 ± 0.03
20B	II (Medium)	1.65 ± 0.03
20C	II (Fine)	1.68 ± 0.10
4-357-XHNS-1-02	I	1.71 ± 0.17
5-98-XHNS-1-05	I	1.18 ± 0.05

^aDipicrylethane

Table II. Radiography Results of HNS Samples
High Density Inclusions

<u>Sample No.</u>	<u>HNS Type</u>	<u>No. > 3 Mils No. < 10 Mils</u>	<u>No. > 10 Mils</u>
1627-2	I	7	0
1627-3	II	0	1
1627-4	II	1	0
1627-5	II Superfine	20	5
1627-6	I	2	1
1627-7	II	3	0
1627-8	I	14	6
1627-9	II	10	9
1627-10	I	11	8
1627-11	II	1	4
1627-12	I	11	4
1627-13	II	1	0
1627-14	I	31	4
1627-15	II	30+	8
1627-16	I	51+	27+
1627-17	II	50+	11
1627-18	I	50+	10
1627-19	II	6	7
22 lb Lot	II	4	26
20A	II (Coarse)	0	7
20B	II (Medium)	0	9
20C	II (Fine)	2	0
4-357-XHNS-1-02	I	24	3
5-98-XHNS-1-05	I	NA	NA

NA - Not Available

Table III. HNS Pressability Study Pellet Density Summary

Sample No.	HNS Type	Pressure (MPa)																				
		7			21			55			110			165			221			276		
		Pellet No.			Pellet No.			Pellet No.			Pellet No.			Pellet No.			Pellet No.			Pellet No.		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1627-2	I				1.154	1.151	1.148	1.325	1.322	1.317	1.472	1.474	1.465	1.553	1.553	1.550	1.588	1.586	1.584	1.619	1.621	1.624
1627-3	II				1.434	1.437	1.436	1.537	1.560	1.546	1.619	1.608	1.616	1.650	1.650	1.647	1.663	1.663	1.662	1.681	1.680	1.680
1627-4	II				1.415	1.405	-	1.522	1.527	1.519	1.585	1.588	1.595	1.619	1.625	1.623	1.647	1.645	1.645	1.659	1.664	1.666
1627-5	II Superfine	0.916	0.914	0.906	1.191	1.190	1.190	1.375	1.372	1.371	1.506	1.512	1.504	1.565	1.566	1.557	1.608	1.605	1.602	1.639	1.641	1.642
1627-6	I				1.148	1.147	1.154	1.332	1.326	1.325	1.469	1.461	1.474	1.533	1.531	1.525	1.577	1.575	1.580	1.623	1.618	1.623
1627-7	II				1.410	1.405	-	1.529	1.531	1.526	1.606	1.504	1.603	1.633	1.636	1.633	1.650	1.649	1.648	1.671	1.669	1.667
1627-8	I				1.140	1.124	1.136	1.320	1.323	1.323	1.466	1.460	1.463	1.539	1.532	1.528	1.579	1.587	1.583	1.622	1.622	1.623
1627-9	II	1.100	1.094	1.100	1.296	1.295	1.292	1.458	1.452	1.448	1.558	1.558	1.553	1.603	1.601	1.601	1.628	1.631	1.629	1.659	1.661	1.657
1627-10	I				1.144	1.141	1.137	1.328	1.330	1.333	1.462	1.457	1.462	1.525	1.523	1.522	1.581	1.582	1.585	1.623	1.625	1.628
1627-11	II				1.395	1.390	1.399	1.515	1.517	1.509	1.601	1.598	1.596	1.626	1.625	1.627	1.652	1.652	1.650	1.670	1.669	1.670
1627-12	I				1.205	1.216	1.210	1.375	1.382	1.378	1.498	1.495	1.492	1.544	1.545	1.542	1.605	1.608	1.605	1.633	1.632	1.630
1627-13	II				1.406	1.400	1.405	1.518	1.519	1.519	1.587	1.588	1.593	1.618	1.622	1.623	1.648	1.644	1.647	1.662	1.663	1.660
1627-14	I				1.143	1.142	1.147	1.333	1.331	1.327	1.474	1.471	1.464	1.544	1.547	1.548	1.584	1.576	1.586	1.620	1.614	1.620
1627-15	II	1.064	1.066	-	1.266	1.264	1.267	1.431	1.435	1.437	1.540	1.536	1.537	1.633	1.635	1.634	1.587	1.589	1.588	1.649	1.646	1.645
1627-16	I	1.057	1.061	1.054	1.268	1.267	1.261	1.428	1.433	1.433	1.536	1.536	1.547	1.592	1.590	1.591	1.630	1.632	1.633	1.644	1.642	1.650
1627-17	II	1.098	1.096	1.092	1.338	1.314	1.311	1.464	1.469	1.465	1.572	1.569	1.568	1.609	1.606	1.606	1.642	1.651	1.649	1.659	1.655	1.666
1627-18	I	0.950	0.954	0.954	1.237	1.236	1.236	1.401	1.398	1.392	1.516	1.515	1.516	1.565	1.562	1.562	1.623	1.621	1.624	1.645	1.645	1.638
1627-19	II	1.199	1.213	1.223	1.385	1.387	1.389	1.510	1.506	1.514	1.593	1.590	1.597	1.625	1.628	1.628	1.661	1.664	1.655	1.671	1.671	1.671
4-357-XHNS-1-02					1.155	1.146	1.141	1.355	1.350	1.342	1.456	1.459	1.456	1.545	1.546	1.541	1.588	1.587	1.585	1.608	1.614	1.613
5-98-XHNS-1-05					1.155	1.158	1.152	1.356	1.350	1.344	1.480	1.469	1.461	1.547	1.544	1.545	1.594	1.589	1.592	1.615	1.613	1.618
22 lb Lot	II	1.227	1.225	1.226	1.381	1.385	1.367	1.507	1.507	1.506	1.602	1.597	1.597	1.627	1.628	1.627	1.647	1.646	1.648	1.662	1.659	1.663
20A	II (Coarse)				1.478	1.474	1.471	1.562	1.558	1.565	1.620	1.621	1.619	1.647	1.648	1.644	1.659	1.659	1.659	1.668	1.668	1.667
20B	II (Medium)				1.356	1.354	1.353	1.490	1.500	1.494	1.584	1.586	1.585	1.623	1.626	1.626	1.647	1.647	1.644	1.656	1.659	1.662
20C	II (Fine)				1.325	1.328	1.327	1.476	1.476	1.475	1.571	1.572	1.572	1.613	1.613	1.613	1.642	1.637	1.640	1.656	1.656	1.657

Table IV. HNS Pressability Study Pellet Rebound Summary

Sample No.	HNS Type	Pellet Density (Mg/m ³)/Pellet Rebound (mm/m)						
		Reference Pressure (MPa)						
		7	21	55	110	165	221	276
1627-2	I		1.142/45.2	1.325/32.1	1.470/33.5	1.554/36.6	1.589/41.7	1.616/48.2
1627-3	II		1.434/11.1	1.530/14.2	1.605/23.4	1.652/34.5	1.666/41.4	1.679/55.7
1627-4	II		1.401/20.0	1.517/20.8	1.599/29.2	1.620/33.3	1.645/39.7	1.654/44.7
1627-5	II Superfine	0.903/85.0	1.195/38.3	1.375/29.3	1.509/30.2	1.571/34.1	1.602/38.6	1.645/48.3
1627-6	I		1.142/58.4	1.325/40.3	1.463/35.8	1.533/35.9	1.582/41.2	1.620/49.2
1627-7	II		1.403/15.2	1.527/18.6	1.600/24.4	1.634/32.2	1.650/37.7	1.663/45.8
1627-8	I		1.130/51.3	1.324/29.6	1.462/32.0	1.532/35.1	1.589/40.1	1.626/46.4
1627-9	II	1.093/23.8	1.307/18.7	1.448/19.0	1.555/24.9	1.606/30.4	1.626/36.5	1.655/47.0
1627-10	I		1.138/60.8	1.325/34.1	1.456/36.5	1.520/37.7	1.579/41.9	1.624/52.0
1627-11	II		1.388/15.9	1.507/16.6	1.596/26.0	1.627/33.7	1.649/39.5	1.668/53.6
1627-12	I		1.218/51.7	1.371/37.1	1.497/36.4	1.542/40.6	1.607/48.3	1.625/53.8
1627-13	II		1.406/18.7	1.517/23.6	1.589/30.6	1.616/33.9	1.638/39.0	1.660/48.4
1627-14	I		1.151/58.0	1.329/36.7	1.473/35.8	1.547/40.9	1.585/44.0	1.613/49.2
1627-15	II	1.068/41.6	1.264/22.5	1.440/24.6	1.539/28.0	1.595/33.7	1.632/40.8	1.644/46.8
1627-16	I	1.054/32.4	1.263/22.5	1.432/21.1	1.532/24.5	1.585/30.4	1.627/37.3	1.645/46.3
1627-17	II	1.099/32.7	1.321/22.2	1.464/22.7	1.563/27.6	1.602/33.5	1.643/40.8	1.649/43.7
1627-18	I	0.959/88.0	1.233/28.3	1.396/25.3	1.515/29.1	1.569/32.4	1.619/40.4	1.637/46.5
1627-19	II	1.216/18.6	1.395/13.5	1.509/16.5	1.588/23.5	1.627/30.4	1.653/37.9	1.666/49.6
4-357-XHNS-1-02			1.145/60.0	1.353/38.6	1.455/38.3	1.546/38.3	1.582/48.0	1.619/58.0
5-98-XHNS-1-05			1.150/57.7	1.357/37.5	1.468/37.5	1.547/36.6	1.594/44.5	1.614/49.4
22 lb Lot	II	1.228/16.9	1.380/10.8	1.505/12.4	1.595/20.6	1.626/25.5	1.644/32.8	1.662/38.2
20A	II (Coarse)		1.481/13.8	1.560/14.5	1.618/23.4	1.644/31.0	1.662/39.2	1.671/47.1
20B	II (Medium)		1.353/18.5	1.495/17.6	1.587/24.5	1.619/29.7	1.647/37.5	1.665/45.8
20C	II (Fine)		1.328/16.5	1.474/17.2	1.571/24.1	1.610/30.1	1.636/37.2	1.657/43.3

Fig. 1. Schematic of 7.6 mm Diameter Punch and Die Set Used for HNS Pressability Study

Fig. 2. HNS I Pressing Results, Sample No. 1627-2, Bulk Density 0.23

Fig. 3. HNS II Pressing Results, Sample No. 1627-3, Bulk Density 0.83

Fig. 4. HNS II Pressing Results, Sample No. 1627-4, Bulk Density 0.74

Fig. 5.. HNS II Superfine Pressing Results, Sample No. 1627-5, Bulk Density 0.42

Fig. 6. HNS I Pressing Results, Sample No. 1627-6, Bulk Density 0.27

Fig. 7. HNS II Pressing Results, Sample No. 1627-7, Bulk Density 0.74

Fig. 8. HNS I Pressing Results, Sample No. 1627-8, Bulk Density 0.24

Fig. 9. HNS II Pressing Results, Sample No. 1627-9, Bulk Density 0.50

Fig. 10. HNS : Pressing Results, Sample No. 1627-10, Bulk Density 0.17

Fig. 11. HNS II Pressing Results, Sample No. 1627-11, Bulk Density 0.77

Fig. 12. HNS I Pressing Results, Sample No. 1627-12, Bulk Density 0.16

Fig. 13. HNS II Pressing Results, Sample No. 1627-13, Bulk Density 0.48

Fig. 14. HNS I Pressing Results, Sample No. 1627-14, Density 0.16

Fig. 15. HNS II Pressing Results, Sample No. 1627-15, Bulk Density 0.39

Fig. 16. HNS I Pressing Results, Sample No. 1627-16, Bulk Density 0.37

Fig. 17. HNS II Pressing Results, Sample No. 1627-17, Bulk Density 0.44

Fig. 18. HNS I Pressing Results, Sample No. 1627-18, Bulk Density 0.23

Fig. 19. HNS II Pressing Results, Sample No. 1627-19, Bulk Density 0.71

Fig. 20. HNS I Pressing Results, Sample No. 4-357-XHNS-1-02, Bulk Density 0.25

Fig. 21. HNS I Pressing Results, Sample No. 5-98-XHNS-1-05, Bulk Density 0.25

Fig. 22. HNS II Pressing Results, 22 lb Lot, Bulk Density 0.71

Fig. 23. HNS II Pressing Results, Sample No. 20A (Coarse), Bulk Density 1.00

Fig. 24. HNS II Pressing Results, Sample No. 20B (Medium), Bulk Density 0.66

Fig. 25. HNS II Pressing Results, Sample No. 20C (Fine), Bulk Density 0.63

Fig. 26. Pellet Density Versus Bulk Density of HNS Samples 1627-2 Through 1627-19 (Except 1627-5)