FFI RAPPORT

Mechanical testing by uniaxial compressive test of DPX-6

Gunnar Ove Nevstad

FFI/RAPPORT-2007/01664

Mechanical testing by uniaxial compressive test of DPX-6

Gunnar Ove Nevstad

FFI/RAPPORT-2007/01664

FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
P O Box 25, NO-2027 Kjeller, Norway

FORSVARETS FORSKNINGSINSTITUTT (FFI)
Norwegian Defence Research Establishment

P O BOX 25
N0-2027 KJELLER, NORWAY

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE
(when data entered)

REPORT DOCUMENTATION PAGE

1) PUBL/REPORT NUMBER	2) SECURITY CLASSIFICATION	3) NUMBER OF PAGES
FFI/RAPPORT-2007/01664	UNCLASSIFIED	32
1a) PROJECT REFERENCE	**2a) DECLASSIFICATION/DOWNGRADING SCHEDULE**	
FFI-V/873/130	-	

4) TITLE

MECHANICAL TESTING BY UNIAXIAL COMPRESSIVE TEST OF DPX-6

5) NAMES OF AUTHOR(S) IN FULL (surname first)

NEVSTAD Gunnar Ove

6) DISTRIBUTION STATEMENT

Approved for public release. Distribution unlimited. (Offentlig tilgjengelig)

7) INDEXING TERMS

IN ENGLISH:	IN NORWEGIAN:
a) PBX	a) PBX
b) Pressing	b) pressing
c) Compression	c) kompresjon
d) Mechanical Properties	d) mekaniske egenskaper
e) DPX-6	e) DPX-6

THESAURUS REFERENCE:

8) ABSTRACT

DPX-6 is a press-filled PBX containing HMX and Aluminium powder as the main components. The content of HMX is 50 wt% while the content of aluminium is 45.9 wt%. The last 4.1 wt% is the binder (Hytemp/DOA) of which 73 wt% is the plasticizer DOA.

We have in this report pressed pellets at room temperature to an average density of 2.038 g/cm^{3}or 97% of TMD. These pellets have been used to characterize the mechanical properties at – 50, 20, 40 and 60^{o}C by uniaxial compression test. The obtained max stress properties go from 35 MPa at -50^{o}C to 12.8 MPa at 60^{o}C, while the corresponding strain at max stress goes from 6.0 % to 4.78 %.

9) DATE	AUTHORIZED BY	POSITION
	This page only	
2007-06-22	Jan Ivar Botnan	Director

ISBN 978-82-464-1212-2

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE
(when data entered)

CONTENTS

Mechanical testing by uniaxial compressive test of DPX-6

1 INTRODUCTION

M72 LAW (Light Antiarmour Weapon) has been redesigned with a new warhead for urban warfare. M72 ASM-RC (Anti-Structure Munition Reduced Caliber) has as the name indicates a new warhead for combat of light buildings. This requires a main charge explosive different from that used in shaped charge warheads. A candidate as main charge explosive is DPX-6, an aluminized PBX which is press filled into the warhead. This composition has lately been qualified according to STANAG 4170 (1) and accompanying AOP-7 (2). Uniaxial compressive properties are not a separate test of the qualification programme, but these properties were in the qualification obtained as part of an ageing programme (3).

Here we will report on uniaxial compressive properties of DPX-6 pellets pressed at room temperature. The uniaxial compressive test has been performed according to STANAG 4443 (4).

2 EXPERIMENTALLY

2.1 Pressing

All pellets tested in this report have been pressed at FFI. The pellets have been pressed by a force of 6.8 tons at room temperature with a dwell time of 60 seconds. In Appendix A is given the control report for the used explosive composition.

2.2 Compression Mechanical Properties Testing

The compression testing was performed on a MTS, High Rate Test System on cylindrical charges with diameter 20.88$\pm$0.02 mm and height 21.3$\pm$0.1 mm. The compression rate was 50 mm/min. Precondition time was 2 hours or more. The used test conditions have been as described in STANAG 4443 (4). All pellets have been tested by use of a load cell of 25 kN. Appendix B gives test report sheets for every tested pellet and contain all necessary information about each pellet and the condition under which they were tested. In addition the test report sheet shows the stress-strain curve.

3 RESULTS

3.1 Properties of tested pellets

Tested pellets were pressed with a force of 6.8 tons at room temperature with a dwell time of 60 seconds. The L/D ratio is approximately 1.26. Measured dimensions and weight of each pellet is given in Table 3.1 together with calculated density. Obtained average density 2.038 g/cm^3 is 97% of TMD (TMD =2.1014 g/cm^3). This density is slightly lower than Dyno Nobel has obtained by use of vacuum during pressing (3).

Test Temp. (^{o}C)	Pellet No	Height (mm)	Diameter (mm)	X-Sect. Area (mm^2)	Volume (mm^3)	Weight (g)	Density (g/cm^3)
-50	FFI-1	23.63	18.58	271.13	6406.86	13.0575	2.038
	FFI-2	23.55	18.58	271.13	6385.17	13.0195	2.039
	FFI-3	23.51	18.58	271.13	6374.32	12.9907	2.038
	FFI-4	23.43	18.58	271.13	6352.63	12.9708	2.042
20	FFI-5	23.53	18.58	271.13	6379.74	13.0093	2.039
	FFI-6	23.48	18.58	271.13	6366.19	12.9924	2.041
	FFI-7	23.45	18.58	271.13	6358.05	12.9901	2.043
	FFI-8	23.45	18.59	271.42	6364.90	12.9890	2.041
40	FFI-9	23.47	18.59	271.42	6370.33	12.9742	2.037
	FFI-10	23.62	18.60	271.72	6417.94	13.0389	2.032
	FFI-11	23.50	18.60	271.72	6385.33	13.0099	2.037
	FFI-12	23.43	18.59	271.42	6359.47	12.9515	2.037
60	FFI-13	23.61	18.59	271.42	6408.33	13.0401	2.035
	FFI-14	23.64	18.60	271.72	6423.37	13.0760	2.036
	FFI-15	23.45	18.60	271.72	6371.75	12.9600	2.034
	FFI-16	23.55	18.59	271.42	6392.04	12.9890	2.032
	FFI-17	23.57	18.59	271.42	6397.47	13.0590	2.041
		Average					**2.038 ±0.003**

Table 3.1 Dimensions and weights of pellets used for compression testing.

From the available pellets we set up a test programme for testing of compressive mechanical properties at 4 different temperatures.

3.2 Room temperature

Four pellets, No 5 to 8 were used to test mechanical properties at room temperature. All available information about tested pellets are given in Appendix B.1 which contains a test sheet of each pellet. Figure 3.1 gives a plot of all stress-strain curves, and Table 3.2 summaries the obtained mechanical properties. As Figure 3.1 shows the stress-strain curves for all tested pellets at room temperature have the same form and approximately the same maximum stress.

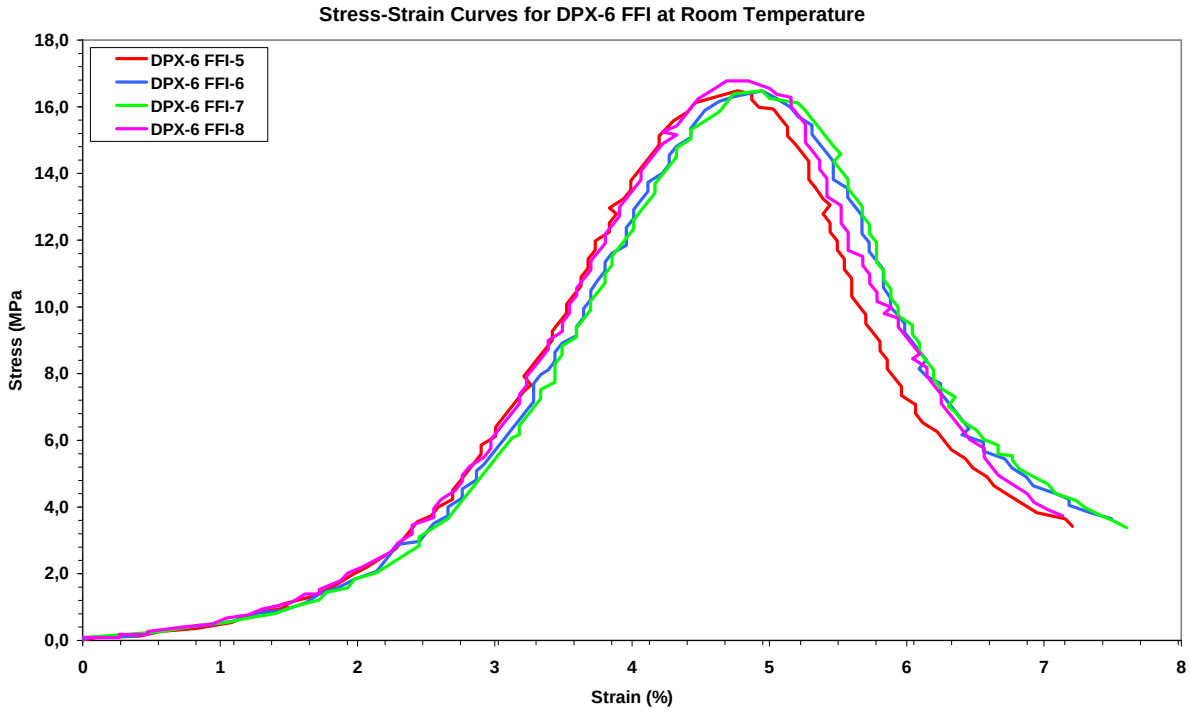


Figure 3.1 Stress-strain curves at room temperature for DPX-6.

Pellet No	Max Stress (MPa)	Strain at Max Stress (%)	E-Modulus (MPa)
DPX-6 FFI-5	16.478	4.77	762.38
DPX-6 FFI-6	16.478	4.95	730.82
DPX-6 FFI-7	16.478	4.95	734.77
DPX-6 FFI-8	16.775	4.85	742.08
Average	**16.55±0.15**	**4.88±0.09**	**742.5±14.0**

Table 3.2 Compressive mechanical properties of DPX-6 at room temperature.

3.3 40°C

At 40°C four pellets, No 9 to 12 were tested. All available information about tested pellets is given in Appendix B.2. Appendix B.2 contains test sheets for every tested pellet. Figure 3.2 gives a plot of all stress-strain curves, and Table 3.3 summaries the obtained mechanical properties. As Figure 3.2 shows, the stress-strain curve for one of the tested pellet (No 10) have not the same form as the curves for the three other pellets, however all stress-strain curves have approximately the same maximum stress. The different stress-strain curve for pellet No 10 is most probably an instrumentation failure rather than a failure in the pellet since it has the same maximum stress as two of the other pellets. The observed variation in properties gives slightly higher standard deviations at 40°C than at room temperature. The stress at 40°C is significantly lower than at room temperature, while the strain at max stress for

the three pellets with normal stress-strain curves is not significantly different from the obtained properties at room temperature.

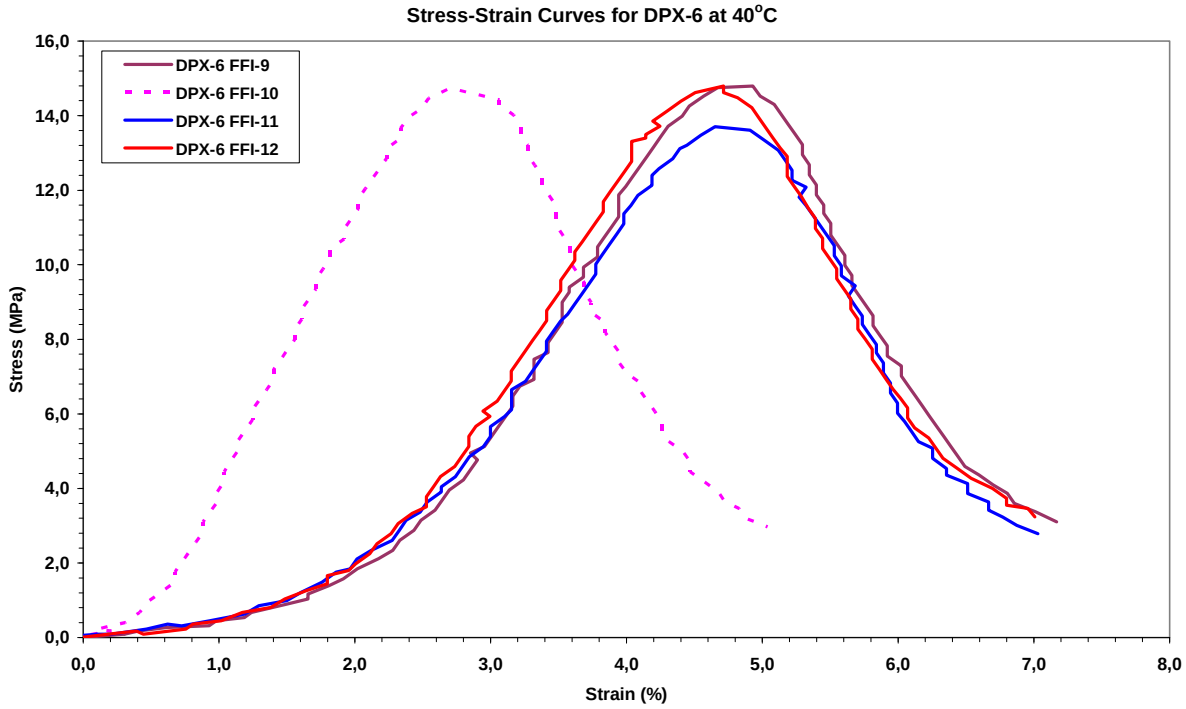


Figure 3.2 Stress-strain curves for DPX-6 tested at 40°C.

Pellet No	Max Stress (MPa)	Strain at Max Stress (%)	E-Modulus (MPa)
DPX-6 FFI-9	14.796	4.93	661.45
DPX-6 FFI-10	13.702	4.85	561.94
DPX-6 FFI-11	14.736	2.70	748.85
DPX-6 FFI-12	14.796	4.71	660.03
Average All	**14.51±0.54**	**4.30±1.07**	**658.1±57.0**
Average all-FFI-11		**4.83±0.11**	**627.8±76.4**

Table 3.3 Compressive mechanical properties of DPX-6 at 40°C temperature.

3.4 60°C

At 60°C we tested 5 pellets, No 13 to 17. All available information about tested pellets is given in Appendix B.3. Appendix B.3 contains test sheets for every tested pellet. Figure 3.3 gives a plot of all stress-strain curves and Table 3.4 summaries the obtained mechanical properties. As Figure 3.3 shows, the stress-strain curves at 60°C are almost identical. From Table 3.4 one finds that the max Stress is 12.8 MPa which is significant lower than at 40°C and at room temperature. The obtained average result with regard to strain at max stress fall within the

standard deviation of the result at room temperature and at 40°C. The average E-modulus at 60°C is significantly lower that at both room temperature and at 40°C.

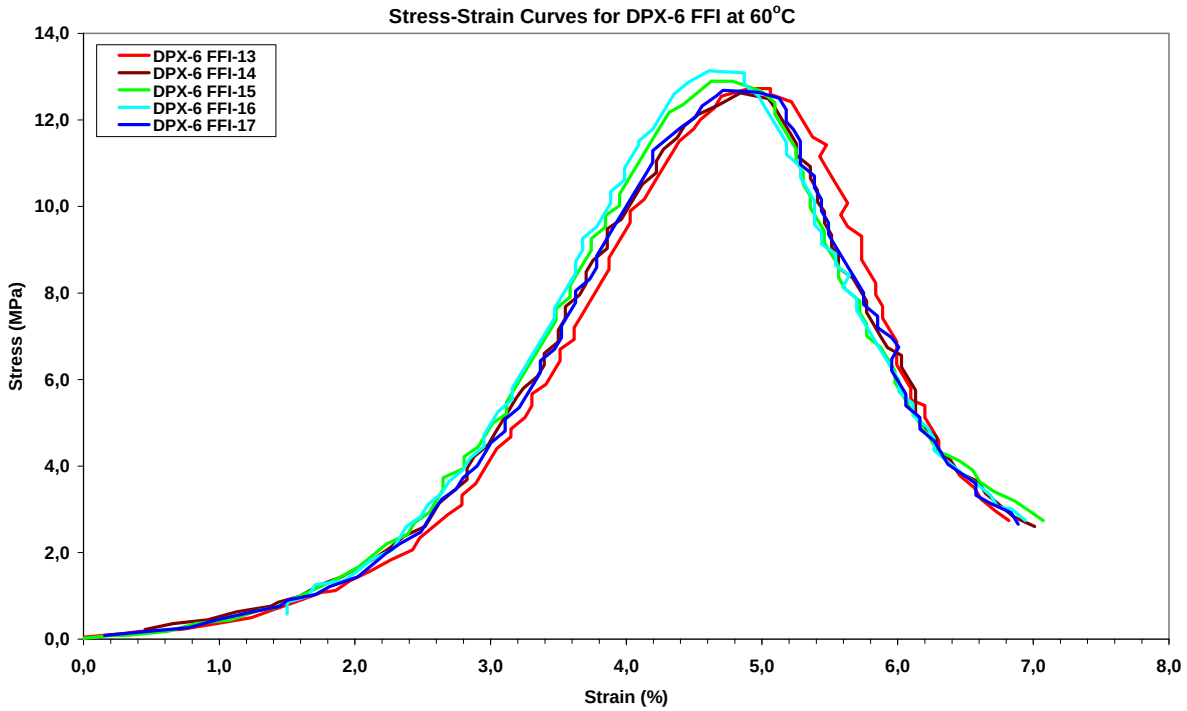


Figure 3.3 Stress-strain curves for DPX-6 tested at 60°C.

Pellet No	Max Stress (MPa)	Strain at Max Stress (%)	E-Modulus (MPa)
DPX-6 FFI-13	12.728	4.99	551.48
DPX-6 FFI-14	12.624	4.84	535.25
DPX-6 FFI-15	12.890	4.76	515.94
DPX-6 FFI-16	13.132	4.61	570.36
DPX-6 FFI-17	12.683	4.71	556.97
Average	**12.81±0.20**	**4.78±0.14**	**546.0±21.0**

Table 3.4 Compressive mechanical properties of DPX-6 at 60°C temperature.

3.5 Low Temperature

At low temperature (-50°C) four pellets were tested. All available information about tested pellets is given in Appendix B.4. Appendix B.4 contains test sheets for every tested pellet. Figure 3.4 gives a plot of all stress-strain curves, and Table 3.5 summaries the obtained mechanical properties. As Figure 3.4 shows the three stress-strain curves at -50°C are almost identical while the fourth curve obtained from pellet FFI-3 is different. From Table 3.5 one finds that the average max stress is 35.1±0.7 MPa which is significantly higher than for the other temperatures. With regard to strain at max stress, the obtained average result at -50°C is slightly higher that at room temperature. The observed E-modulus is significantly higher at low temperature that at room temperature.

Pellet No	Max Stress (MPa)	Strain at Max Stress (%)	E-Modulus (MPa)
DPX-6 FFI-1	35.838	6.05	1306.5
DPX-6 FFI-2	35.568	5.98	1307.3
DPX-6 FFI-3	34.352	6.92	1141.6
DPX-6 FFI-4	34.667	5.94	1249.3
Average All	**35.11±0.71**	**6.22±0.47**	**1251.2±77.9**
Average all -FFI-3		**5.99±0.06**	**1287.7±33.3**

Table 3.5 Compressive mechanical properties of DPX-6 at low temperature.

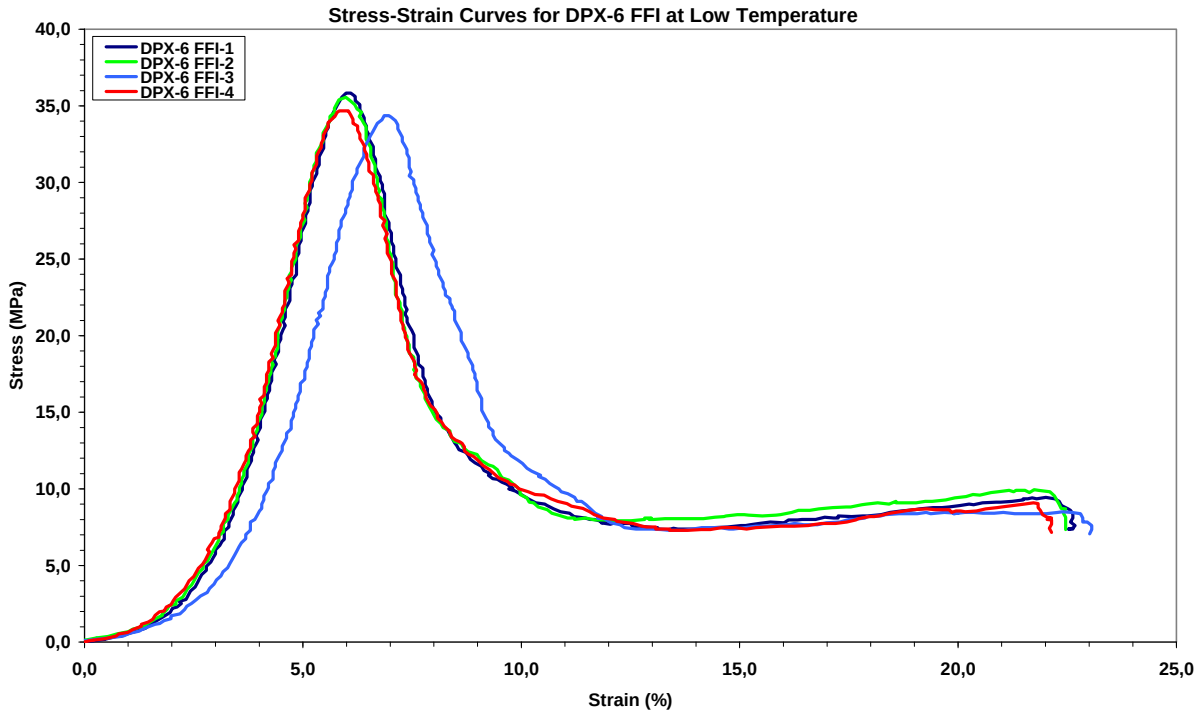


Figure 3.4 Stress-strain curves for DPX-6 FFI pressed pellets at low temperature.

3.6 Comparison

In Table 3.6 has average compressive properties at all test temperatures been summarised.

Temperature (^{o}C)		Max Stress (MPa)	Strain at Max Stress (%)	E-Modulus (MPa)
-50	**Average All**	35.11±0.71	6.22±0.47	1251.2±77.9
	Average all -FFI-3		5.99±0.06	1287.7±33.3
20	**Average**	16.55±0.15	4.88±0.09	742.5±14.0
40	**Average All**	14.51±0.54	4.30±1.07	658.1±57.0
	Average all-FFI-11		4.83±0.11	627.8±76.4
60	**Average**	12.81±0.20	4.78±0.14	546.0±21.0

Table 3.6 Average compressive properties at different temperature for DPX-6.

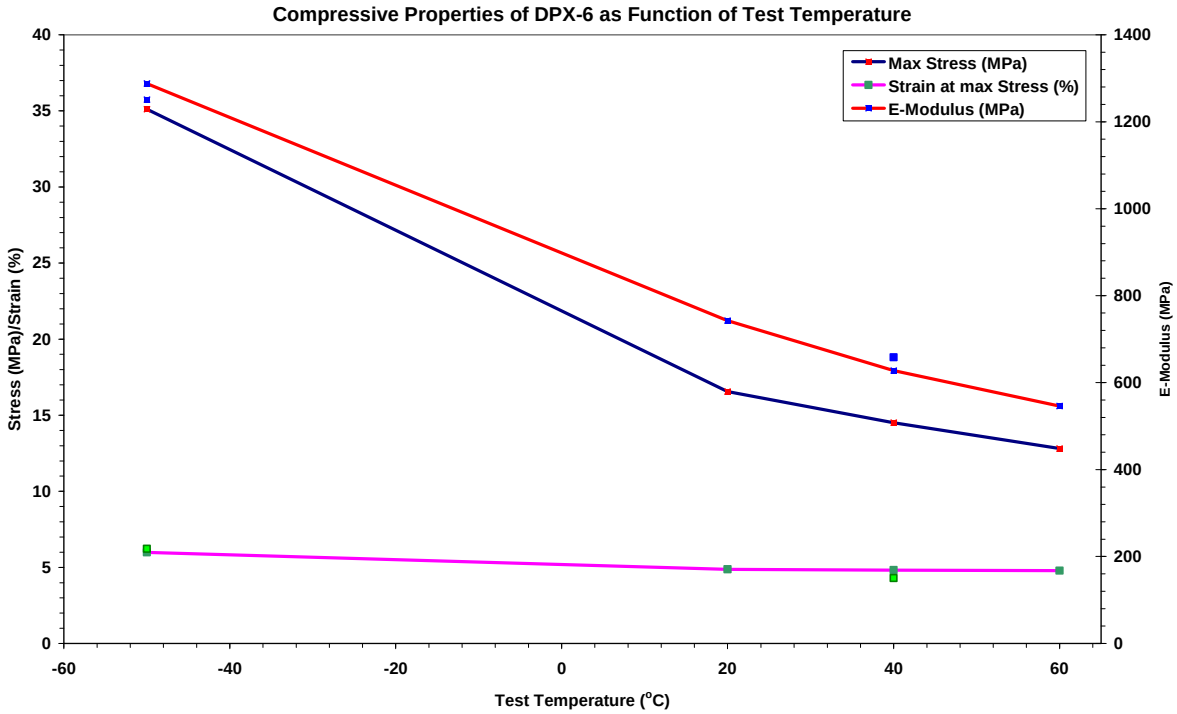


Figure 3.5 Compressive properties as function of test temperature for DPX-6.

Figure 3.5 plots the results in Table 3.6. The plots in Figure 3.5 are close to linear for all measured properties as function of test temperature.

4 SUMMARY

Pellets of DPX-6 were pressed at room temperature to satisfactory density without use of vacuum. These pellets were tested with regard of compressive mechanical properties at four different temperatures from -50°C to +60°C.

In the temperature range from -50°C to +60°C DPX-6 pellets with density 2.04 g/cm^3 have reproducible compressive properties.

APPENDIX

A CONTROL REPORT

DYNO
High Energy Materials

Kontrollrapport
etter EN 10204 – 2.3

Kjøper / Mottaker FFI v/ Gunnar Nevstad	Bestillingsnummer Telf. G.Nevstad	Rapportnummer RD-25/05
	Bestillingsdato 14.03.06	Kontroll dato 25.11.05
Produsent Dyno Nobel ASA N-3476 Sætre NORGE	Produksjonsdato 24.11.05	Offentlig oppdragsnummer
Lot nummer DDP05K0014E	Mengde 725 gram	
Sprengstofftype DPX-6 (PBXW-11 med 45 % Aluminium (kl 6))	Leveringsbetingelser/Teknisk underlag Kun informative verdier, 45 % aluminium	

Analyseresultater

	Sammensetning				Fuktighet	Volumvekt
	HMX	Aluminium	HyTemp	DOA		
KRAV	Informativ	Informativ	Informativ	Informativ	≤ 0,10 %	Informativ
RESULTAT Ch 06/05	50,0	45,9	1,1	3,0	0,02	0,90

	Granulatfordeling, % gjennom USSS Nr.					
	6 (3350 µ)	8 (2360 µ)	12 (1700 µ)	18 (1000 µ)	25 (710 µ)	40 (425 µ)
KRAV	Informativ	Informativ	Informativ	Informativ	Informativ	Informativ
RESULTAT Ch 06/05	100	100	99	55	28	5

Øyvind H. Johansen
FoU Sjef

Kjell-Tore Smith
Forsker

B TEST REPORT SHEETS

B.1 Room Temperature

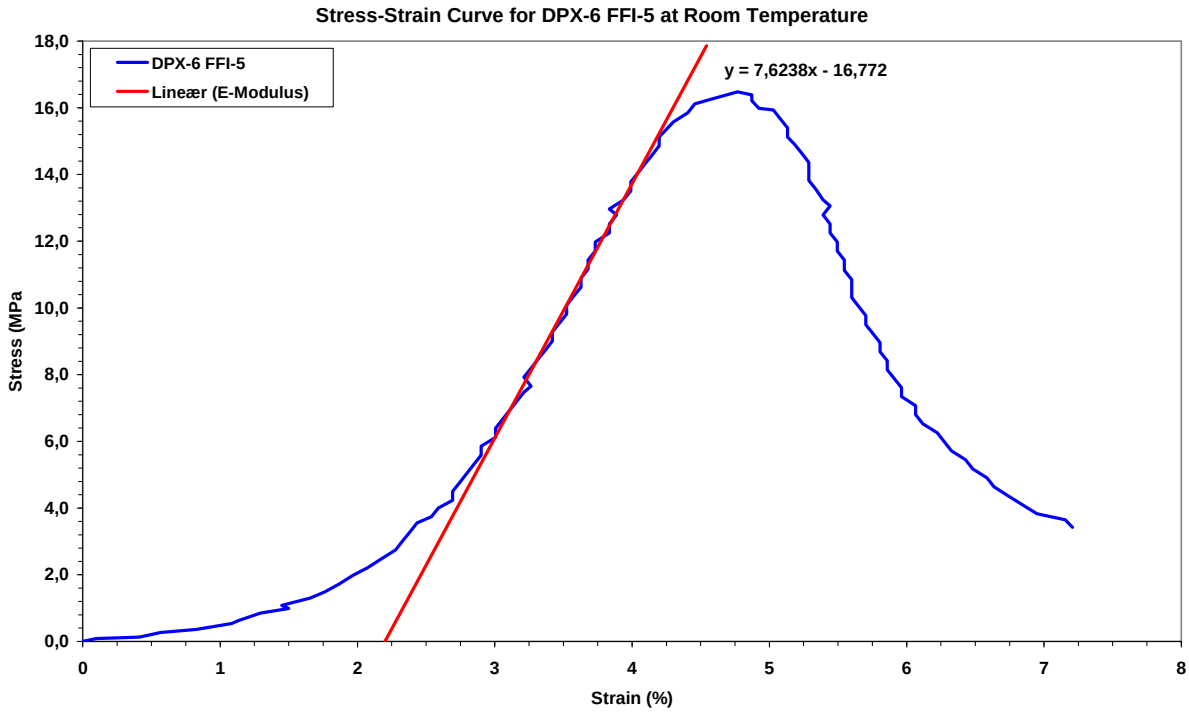
TEST REPORT SHEET
Uniaxial Compressive Test Page 1 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): 20
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.53 mm
Width:
Thickness (Diameter): 18.58 mm
X-Sectional Area (mm^2): 271.13
Form: Cylindrical
Preparation Method: As received L/D=1.2664
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-5
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 16.478 MPa STRAIN at Max Stress: 4.77 % E-Modulus: 762.38 MPa

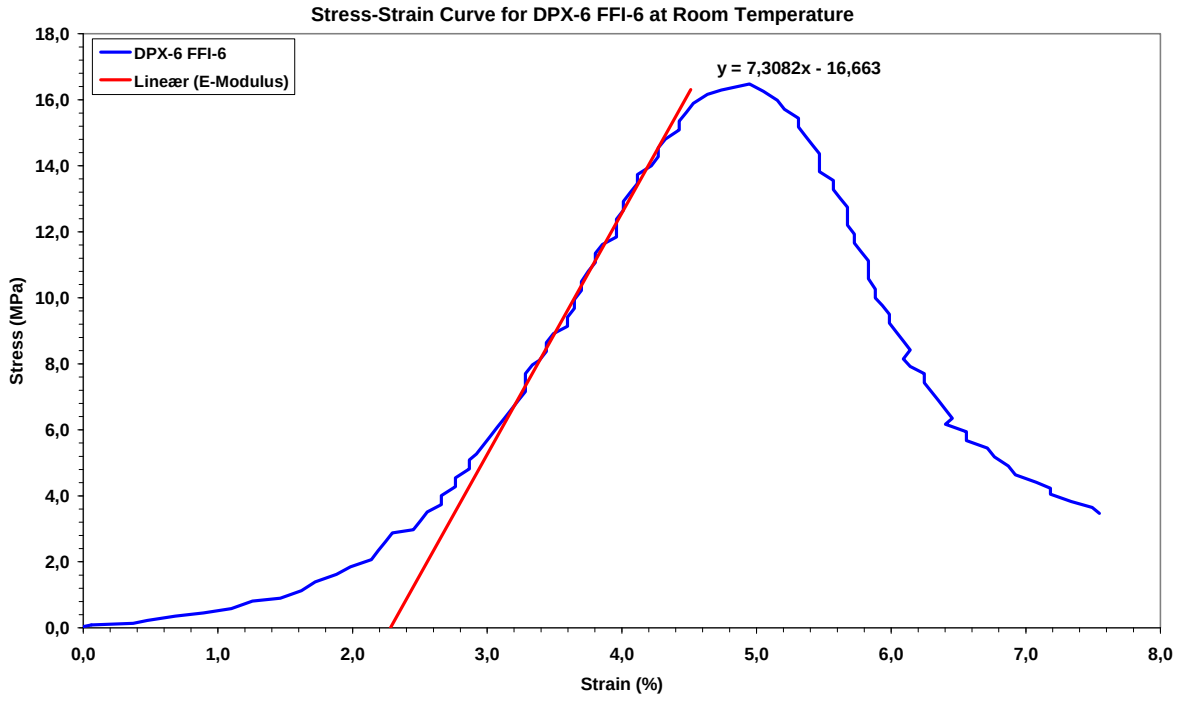
TEST REPORT SHEET
Uniaxial Compressive Test Page 2 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): 20
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.48 mm
Width:
Thickness (Diameter): 18.58 mm
X-Sectional Area (mm^2): 271.13
Form: Cylindrical
Preparation Method: As received L/D=1.2637
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-6
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 16.478 MPa STRAIN at Max Stress: 4.95 % E-Modulus: 730.82 MPa

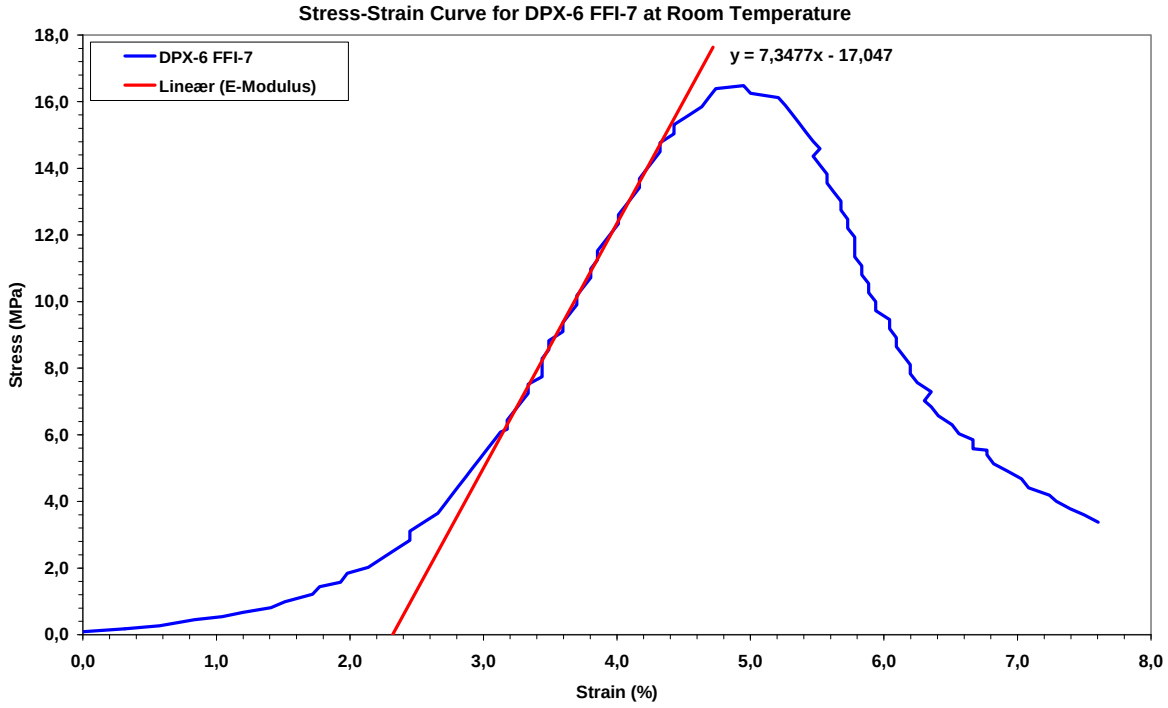
TEST REPORT SHEET
Uniaxial Compressive Test Page 3 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): 20
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.45 mm
Width:
Thickness (Diameter): 18.58 mm
X-Sectional Area (mm^2): 271.13
Form: Cylindrical
Preparation Method: As received L/D=1.0206
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-7
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 16.478 MPa STRAIN at Max Stress: 4.95 % E-Modulus: 734.77 MPa

TEST REPORT SHEET

Uniaxial Compressive Test Page 4 of 4 Pages

TEST SITE INFORMATION

Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

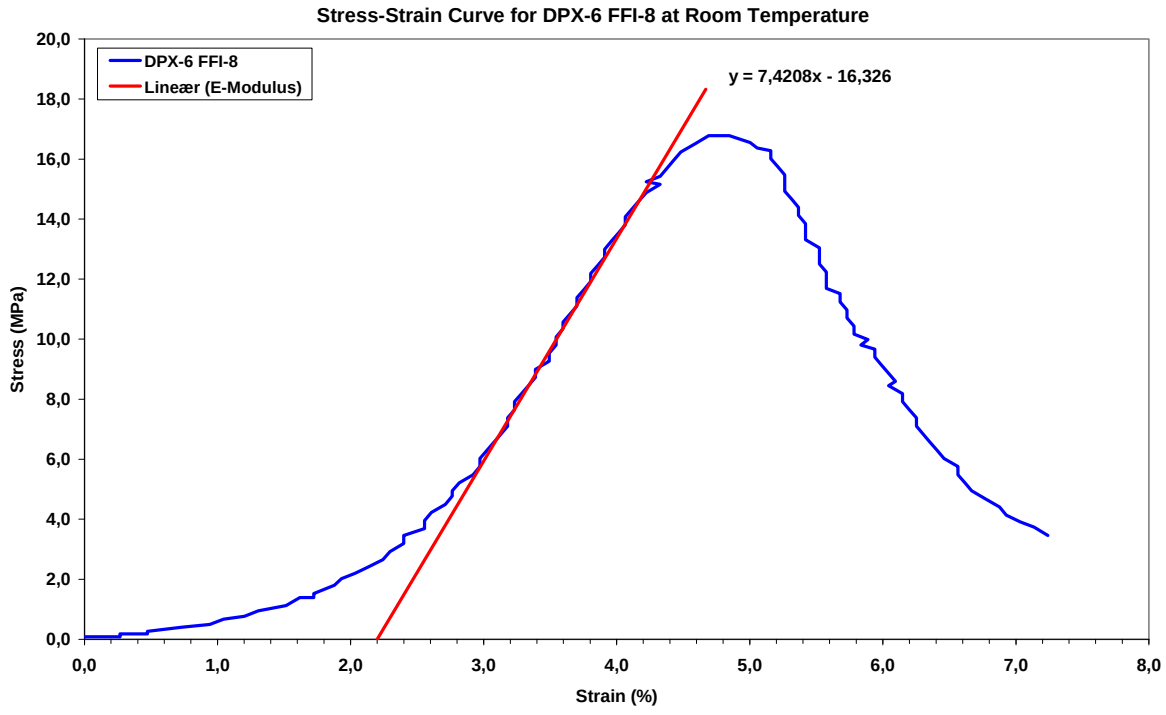
TEST CONDITIONS

Temperature (°C): 20
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION

Dimensions: Length (Gage Length): 23.45 mm
Width:
Thickness (Diameter): 18.59 mm
X-Sectional Area (mm^2): 271.42
Form: Cylindrical
Preparation Method: As received L/D=1.261
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-8
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 16.775 MPa STRAIN at Max Stress: 4.85 % E-Modulus: 742.08 MPa

B.2 40°C

TEST REPORT SHEET
Uniaxial Compressive Test Page 1 of 4 Pages

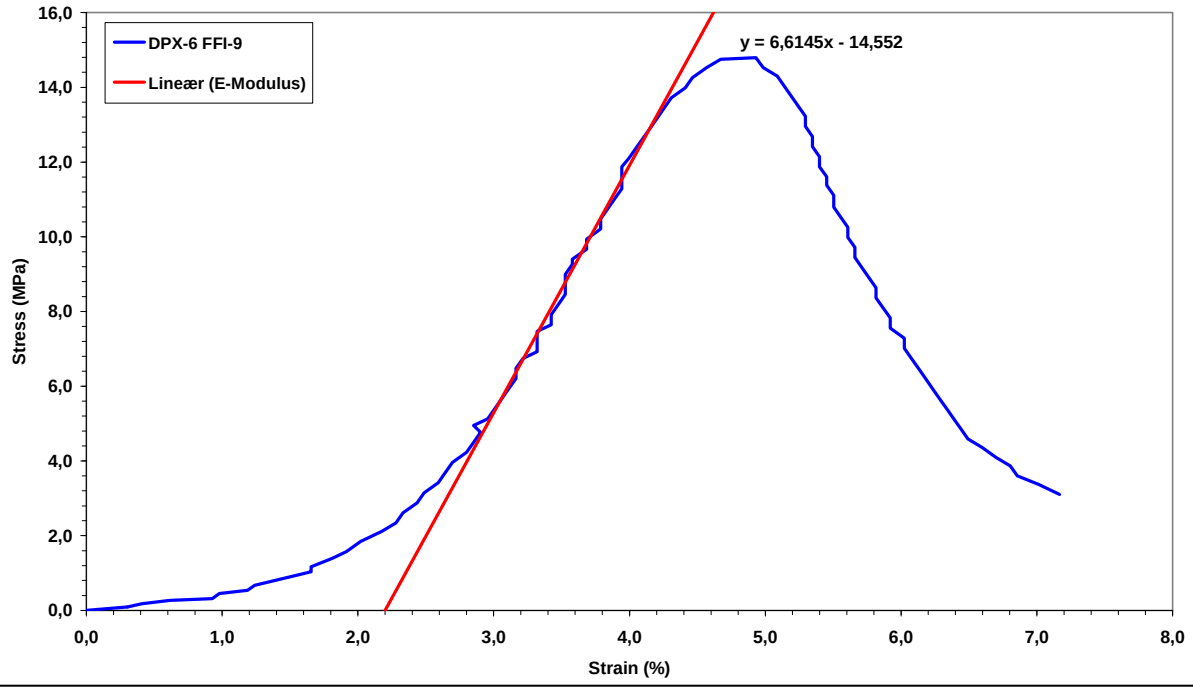
TEST SITE INFORMATION	TEST CONDITIONS
Laboratory: FFI	Temperature (°C): 40
Date: 26 November 2006	Relative Humidity (%): NA
Test Procedure:	X-Head Speed (mm/min): 50
NATO Test Procedure Number: 102.01	Machine Type: MTS Servo Hydraulic Tester
Date Tested: 29 October 2006	Grip Type:
POC: Gunnar Ove Nevstad	Machine Stiffness (kN/mm):

SPECIMEN INFORMATION

Dimensions: Length (Gage Length): 23.47 mm
Width:
Thickness (Diameter): 18.59 mm
X-Sectional Area (mm^2): 271.42

Form: Cylindrical
Preparation Method: As received L/D=1.2625
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-9
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 14.796 MPa STRAIN at Max Stress: 4.93 % E-Modulus: 661.45 MPa

TEST REPORT SHEET

Uniaxial Compressive Test Page 2 of 4 Pages

TEST SITE INFORMATION

Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS

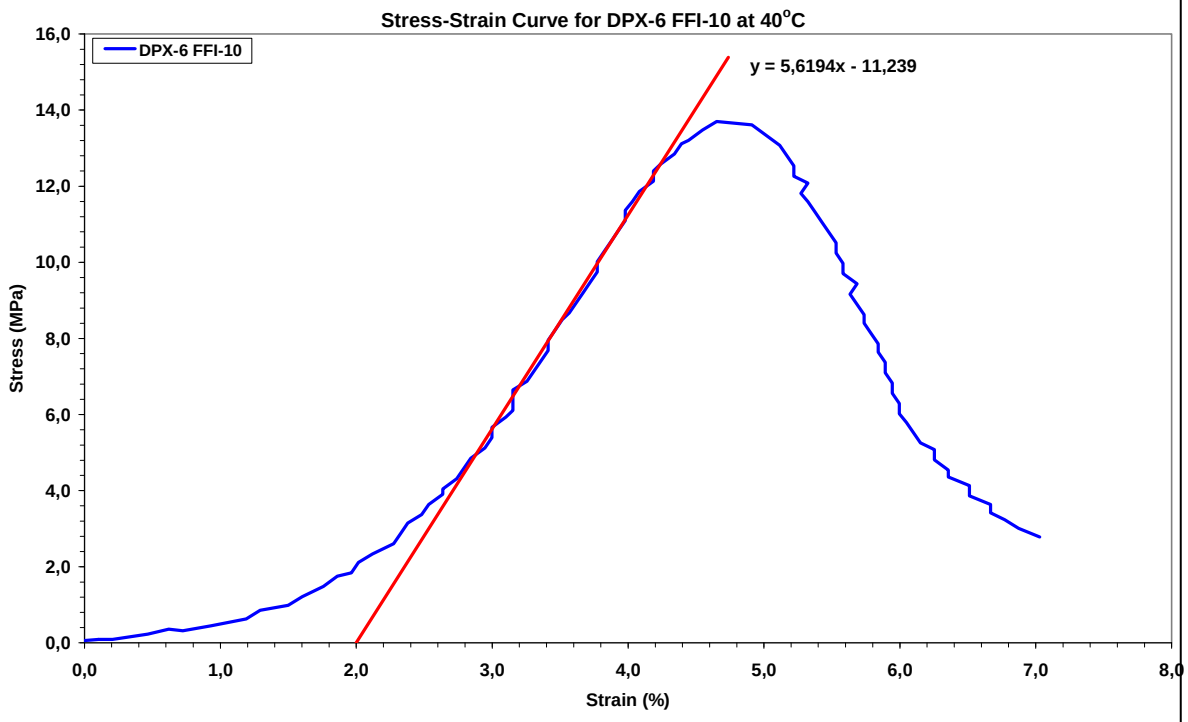
Temperature (°C): 40
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION

Dimensions: Length (Gage Length): 23.62 mm
Width:
Thickness (Diameter): 18.60 mm
X-Sectional Area (mm^2): 271.72

Form: Cylindrical
Preparation Method: As received L/D=1.2699
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-10
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 13.702 MPa STRAIN at Max Stress: 4.85 % E-Modulus: 561.94 MPa

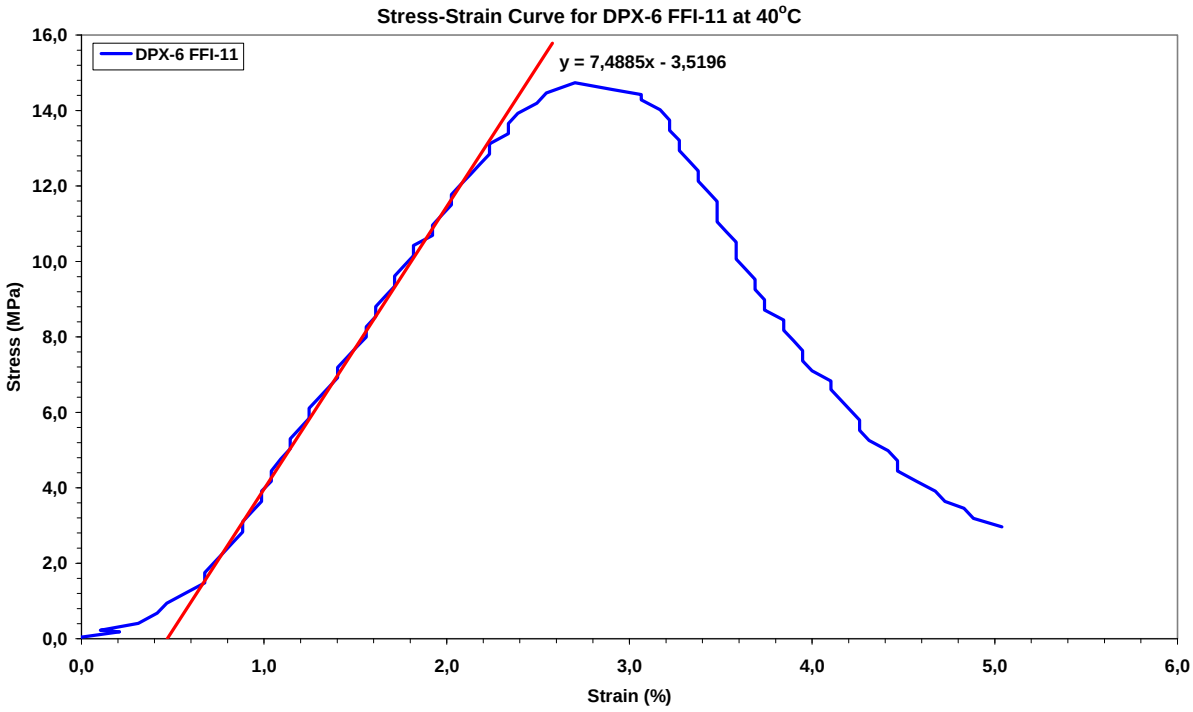
TEST REPORT SHEET
Uniaxial Compressive Test
Page 3 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): 40
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.50 mm
Width:
Thickness (Diameter): 18.6 mm
X-Sectional Area (mm^2): 271.72
Form: Cylindrical
Preparation Method: As received L/D=1.2634
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-11
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 14.736 MPa STRAIN at Max Stress: 2.70 % E-Modulus: 748.85 MPa

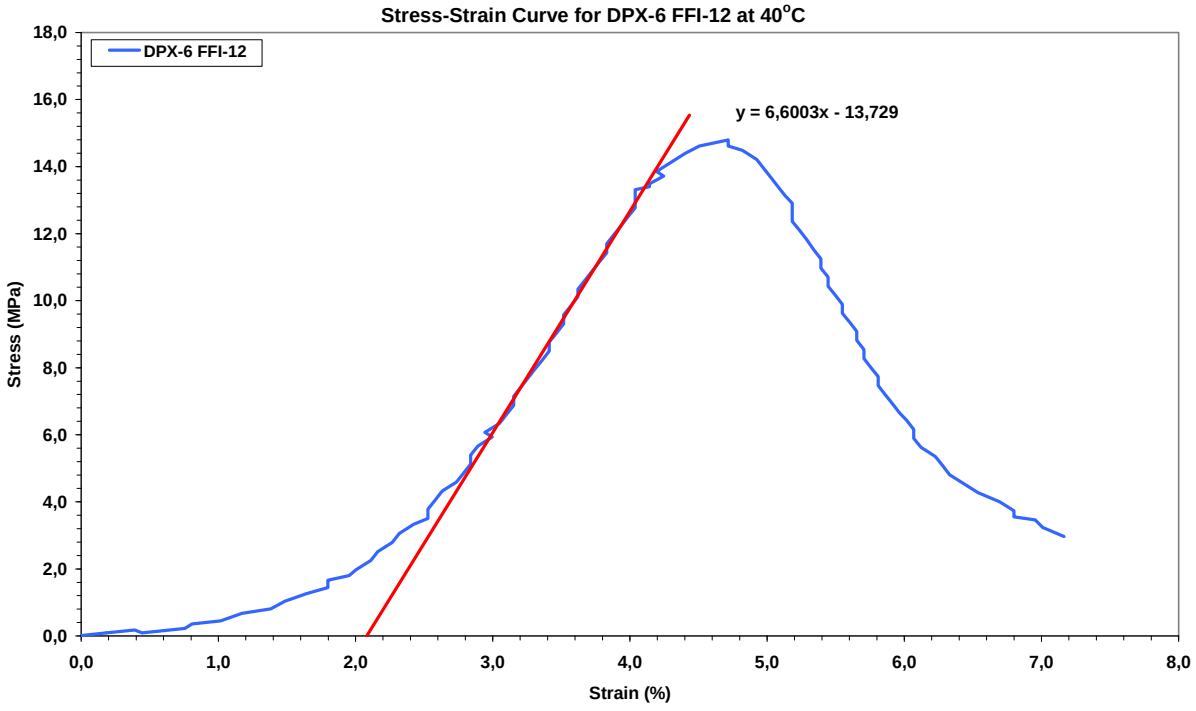
TEST REPORT SHEET
Uniaxial Compressive Test Page 4 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (^{o}C): 40
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.43 mm
Width:
Thickness (Diameter): 18.59 mm
X-Sectional Area (mm^2): 271.42
Form: Cylindrical
Preparation Method: As received L/D=1.2604
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-12
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 14.796 MPa STRAIN at Max Stress: 4.71 % E-Modulus: 660.03 MPa

B.3 60°C

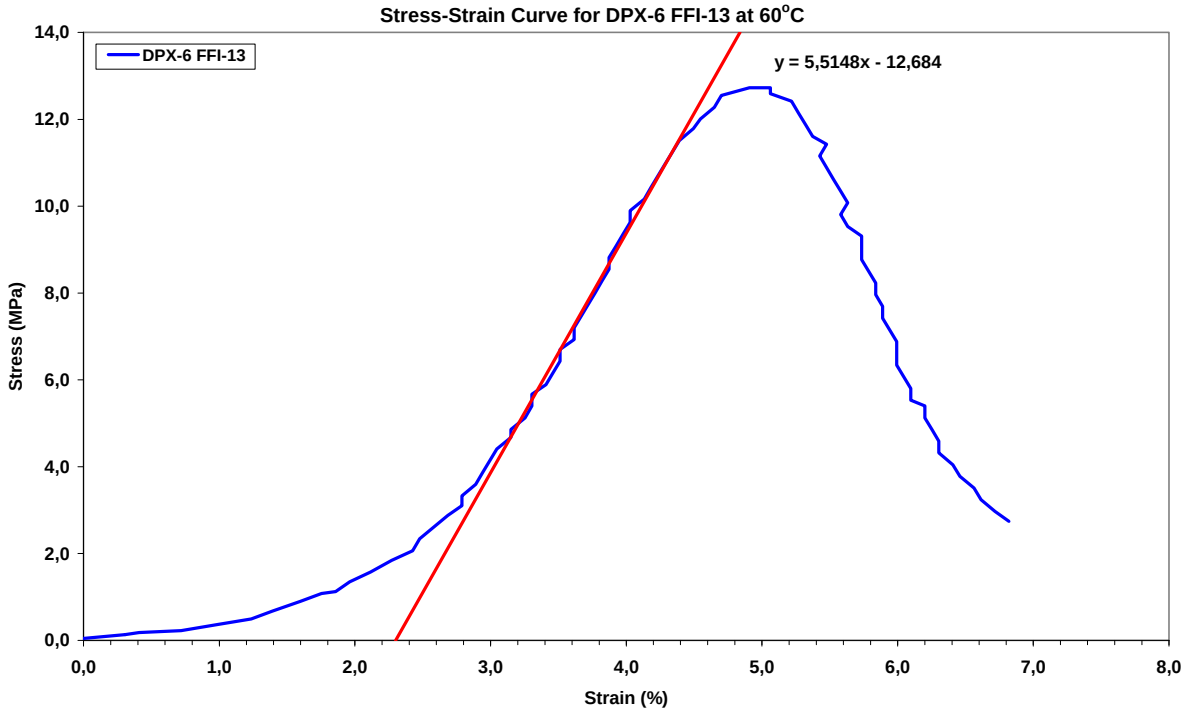
TEST REPORT SHEET
Uniaxial Compressive Test Page 1 of 5 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): 60
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.61 mm
Width:
Thickness (Diameter): 18.59 mm
X-Sectional Area (mm^2): 271.42
Form: Cylindrical
Preparation Method: As received L/D=1.2700
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-13
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 12.728 MPa STRAIN at Max Stress: 4.99 % E-Modulus: 551.48 MPa

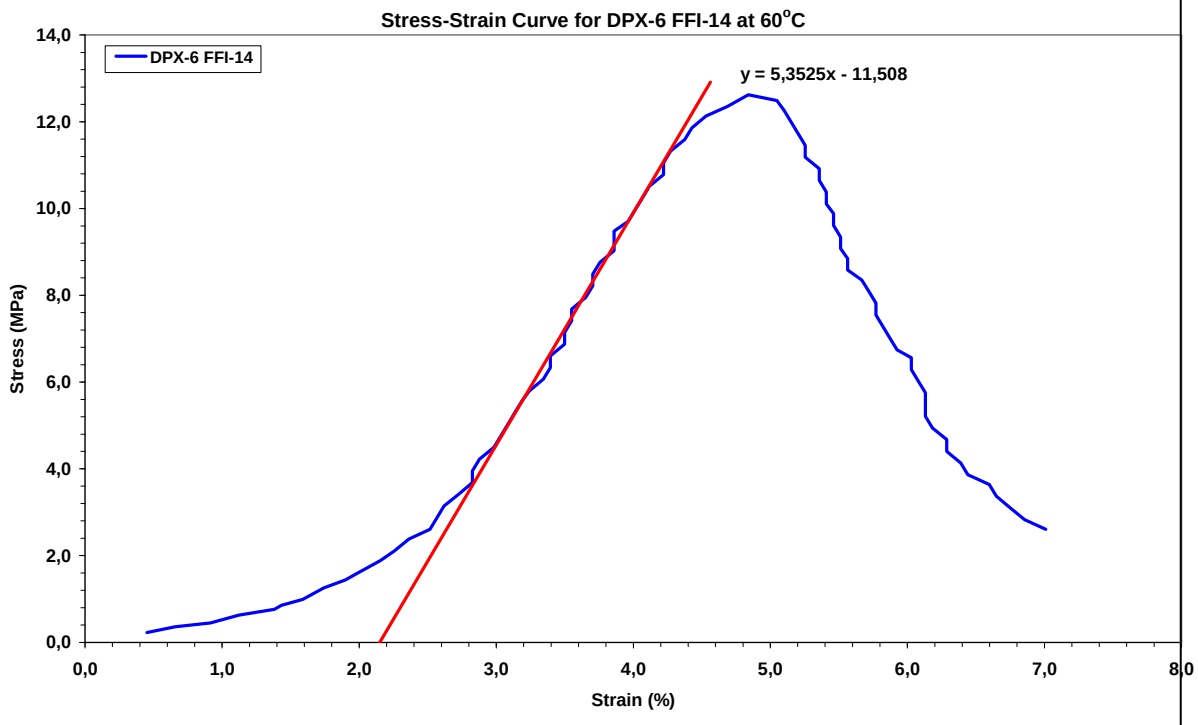
TEST REPORT SHEET
Uniaxial Compressive Test Page 2 of 5 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): 60
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.64mm
Width:
Thickness (Diameter): 18.60 mm
X-Sectional Area (mm^2): 271.72
Form: Cylindrical
Preparation Method: As received L/D=1.2710
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-14
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 12.624 MPa STRAIN at Max Stress: 4.84 % E-Modulus: 535.25 MPa

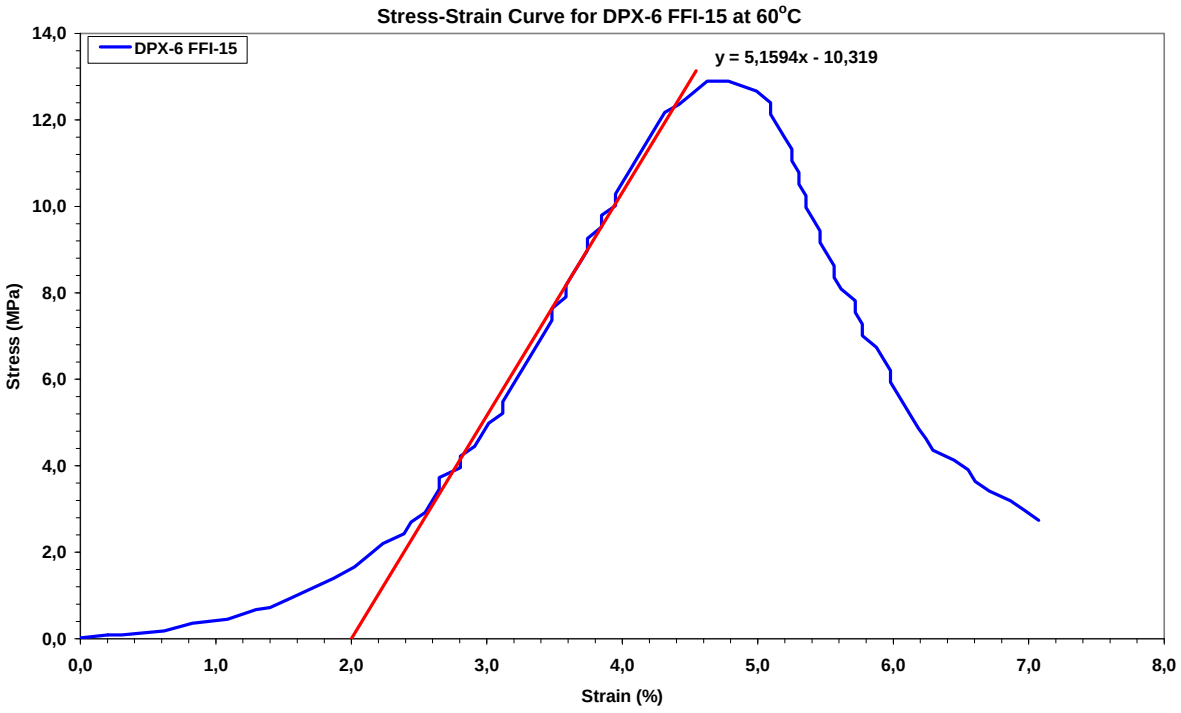
TEST REPORT SHEET
Uniaxial Compressive Test
Page 3 of 5 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): 60
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.45 mm
Width:
Thickness (Diameter): 18.60 mm
X-Sectional Area (mm^2): 271.72
Form: Cylindrical
Preparation Method: As received L/D=1.2608
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-15
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 12.890 MPa STRAIN at Max Stress: 4.76 % E-Modulus: 515.94 MPa

TEST REPORT SHEET
Uniaxial Compressive Test

TEST SITE INFORMATION

Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS

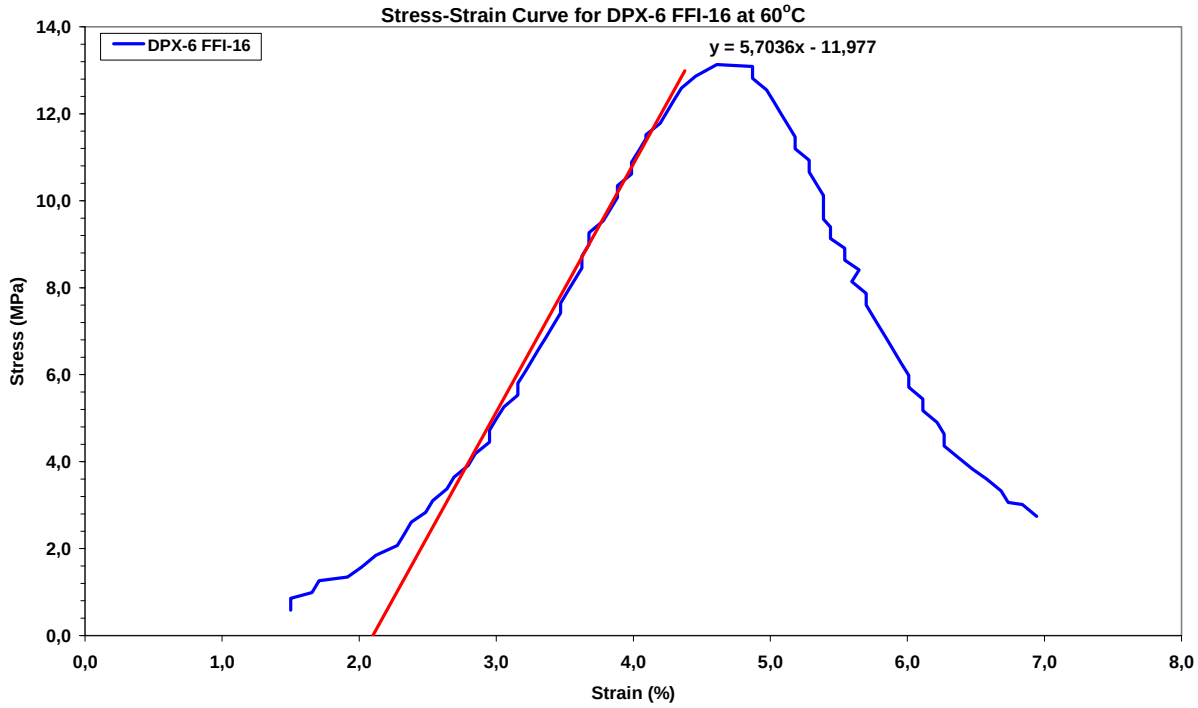
Temperature (^{o}C): 60
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION

Dimensions: Length (Gage Length): 23.55 mm
Width:
Thickness (Diameter): 18.59 mm
X-Sectional Area (mm^2): 271.42

Form: Cylindrical
Preparation Method: As received L/D=1.2668
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-16
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 13.132 MPa STRAIN at Max Stress: 4.61 % E-Modulus: 570.36 MPa

TEST REPORT SHEET

Uniaxial Compressive Test Page 5 of 5 Pages

TEST SITE INFORMATION

Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 29 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS

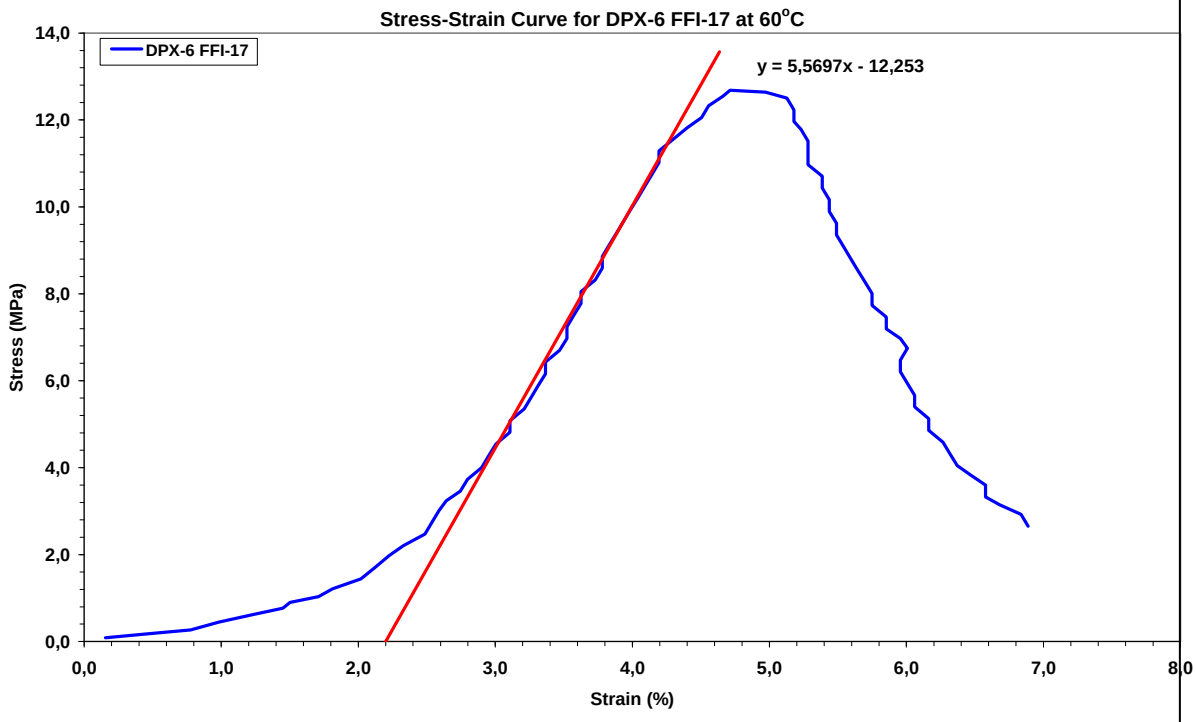
Temperature (°C): 60
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION

Dimensions: Length (Gage Length): 23.57 mm
Width:
Thickness (Diameter): 18.59 mm
X-Sectional Area (mm^2): 271.42

Form: Cylindrical
Preparation Method: As received L/D=1.2679
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-17
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 12.683 MPa STRAIN at Max Stress: 4.71 % E-Modulus: 556.97 MPa

B.4 Low Temperature

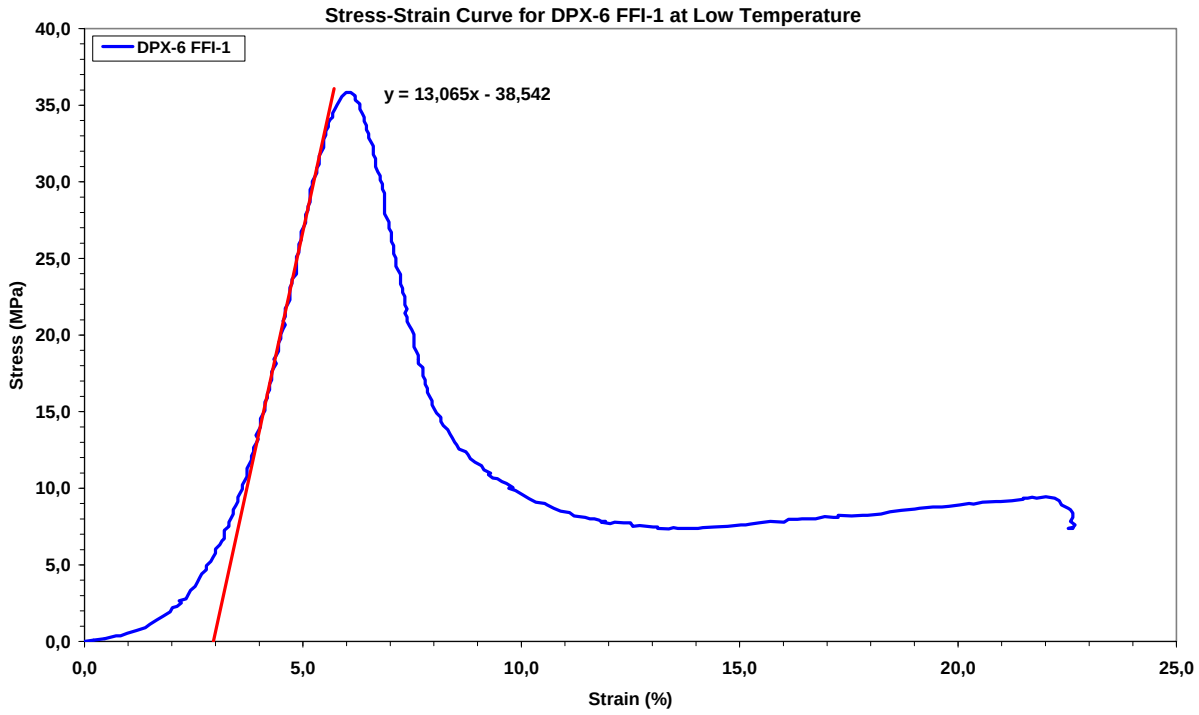
TEST REPORT SHEET
Uniaxial Compressive Test
Page 1 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 28 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): -50
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.63 mm
Width:
Thickness (Diameter): 18.58 mm
X-Sectional Area (mm^2): 271.13
Form: Cylindrical
Preparation Method: As received L/D=1.2718
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-1
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 35.838 MPa STRAIN at Max Stress: 6.05 % E-Modulus: 1306.5 MPa

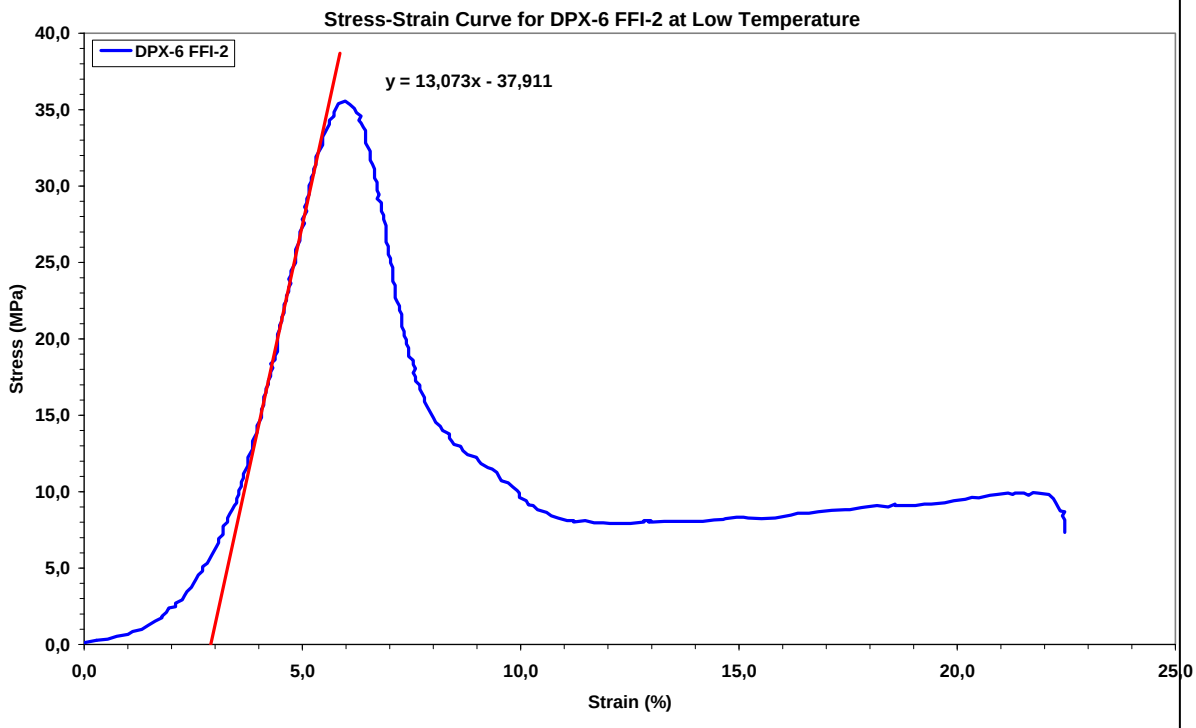
TEST REPORT SHEET
Uniaxial Compressive Test Page 2 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 28 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (°C): -50
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.55 mm
Width:
Thickness (Diameter): 18.58 mm
X-Sectional Area (mm^2): 271.13
Form: Cylindrical
Preparation Method: As received L/D=1.2675
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-2
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 35.568 MPa STRAIN at Max Stress: 5.98 % E-Modulus: 1307.3 MPa

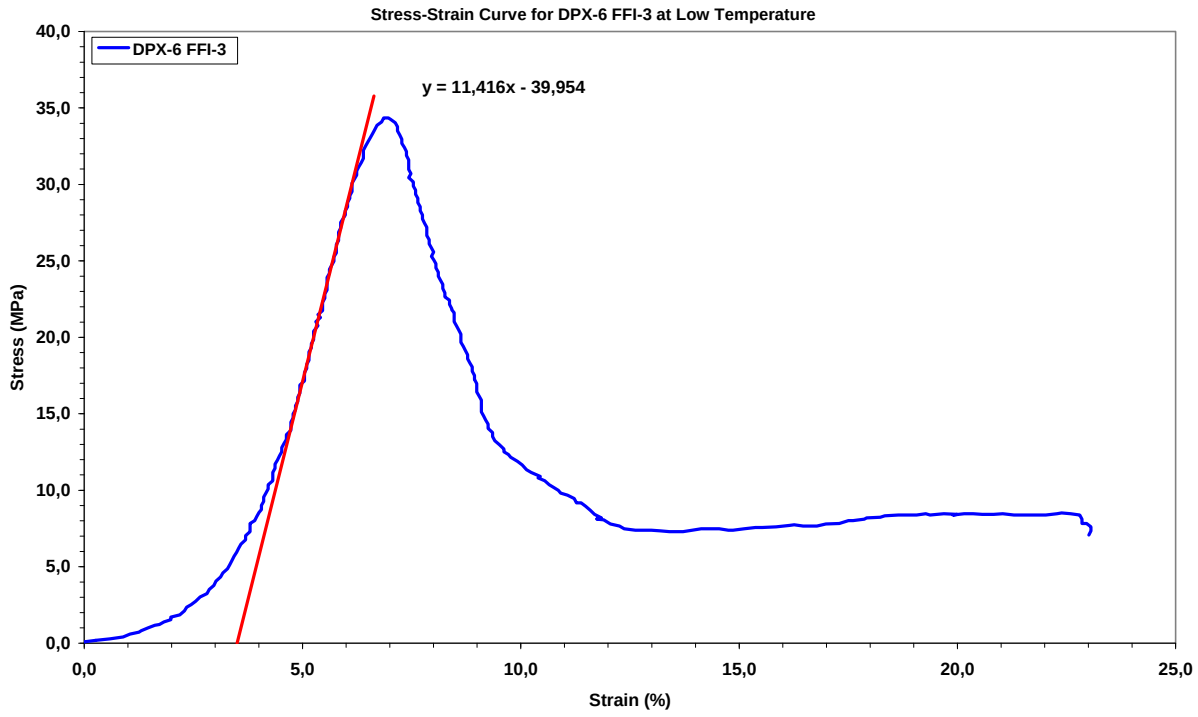
TEST REPORT SHEET
Uniaxial Compressive Test Page 3 of 4 Pages

TEST SITE INFORMATION
Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 28 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS
Temperature (^{o}C): -50
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION
Dimensions: Length (Gage Length): 23.51 mm
Width:
Thickness (Diameter): 18.58 mm
X-Sectional Area (mm^2): 271.13
Form: Cylindrical
Preparation Method: As received L/D=1.2653
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-3
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 34.352 MPa STRAIN at Max Stress: 6.92 % E-Modulus: 1141.6 MPa

TEST REPORT SHEET

Uniaxial Compressive Test Page 4 of 4 Pages

TEST SITE INFORMATION

Laboratory: FFI
Date: 26 November 2006
Test Procedure:
NATO Test Procedure Number: 102.01
Date Tested: 28 October 2006
POC: Gunnar Ove Nevstad

TEST CONDITIONS

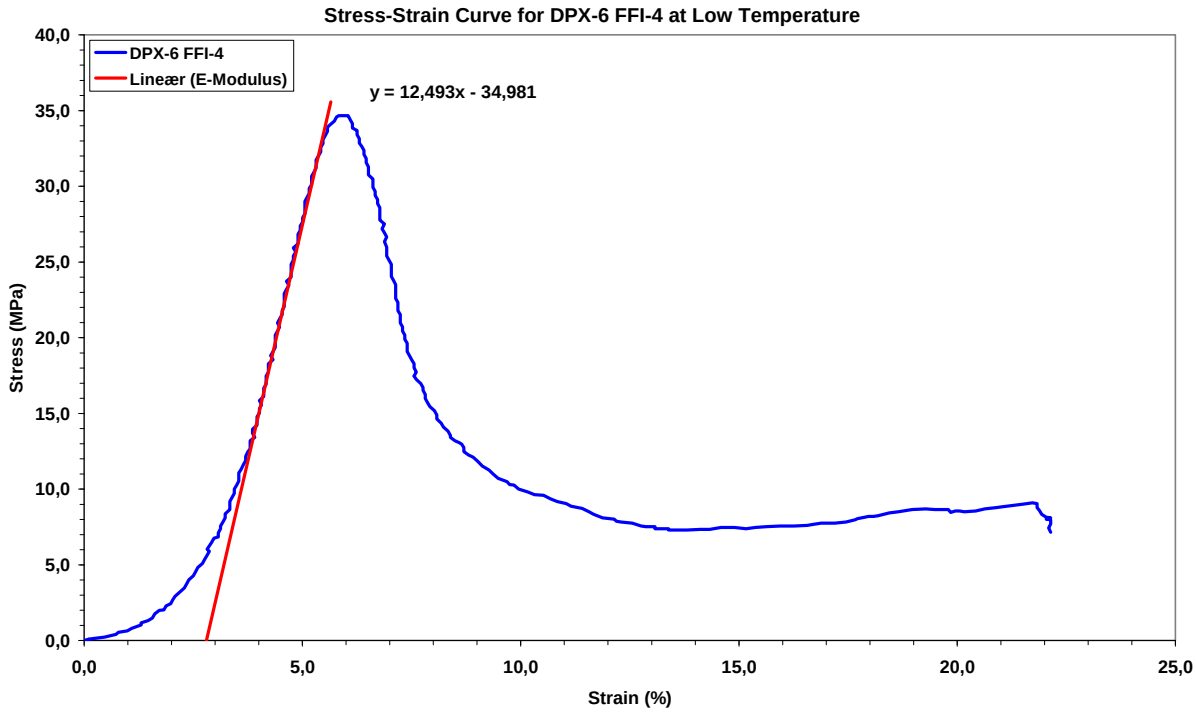
Temperature (°C): -50
Relative Humidity (%): NA
X-Head Speed (mm/min): 50
Machine Type: MTS Servo Hydraulic Tester
Grip Type:
Machine Stiffness (kN/mm):

SPECIMEN INFORMATION

Dimensions: Length (Gage Length): 23.43 mm
Width:
Thickness (Diameter): 18.58 mm
X-Sectional Area (mm^2): 271.13

Form: Cylindrical
Preparation Method: As received L/D=1.2610
Manufacturing Method: Pressed at room temperature, Dwell time 60 s, Force 6.8 ton.
Source: Dyno Nobel
Lot or ID Number: Ch 06/05 Pellet No DPX-6 FFI-4
Preconditioning:
Condition Period: 2 hours
Composition: DPX-6

Component	Percent
HMX	50.0
Aluminium	45.9
DOA	3.0
HYTEMP	1.1



Max STRESS: 34.667 MPa STRAIN at Max Stress: 5.94 % E-Modulus: 1249.3 MPa

References

(1) NATO (AC/326 Subgroup 1) (2001): STANAG 4170 Edition 2, "Principles and Methodology for Qualification of Explosive Materials for Military Use".

(2) NATO /AC/326 Subgroup 1) (2004): AOP-7, Edition 2 Rev. 1, "Manual of Data Requirements and Tests for the Qualification of Explosive Materials for Military Use".

(3) NEVSTAD Gunnar Ove (2006): Mechanical properties of DPX-6 before and after accelerated Ageing at 71^{o}C, FFI/RAPPORT-2006/13686, Unclassified.

(4) NATO /MAS (1998): STANAG 4443 PPS (EDITION 1), "Explosives Uniaxial Compressive Test ". MAS/285-PPS/443, 14 July.