LAWRENCE
LIVERMORE
NATIONAL
LABORATORY

LLNL-TR-426345

SMALL-SCALE SAFETY TEST SUMMARY REPORT-RDX (for triplicates)

P. C. Hsu, J. G. Reynolds

March 25, 2010

Disclaimer

This document was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor Lawrence Livermore National Security, LLC, nor any of their employees makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or Lawrence Livermore National Security, LLC. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or Lawrence Livermore National Security, LLC, and shall not be used for advertising or product endorsement purposes.

This work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under Contract DE-AC52-07NA27344.

LAWRENCE LIVERMORE NATIONAL LABORATORY

From: Peter C. Hsu PCH
Title: Small-scale Safety Test Summary Report-RDX (for triplicates)
L-282, P.O. Box 808
(925) 422-0317 telephone
(925) 424-3281 fax
Email: hsu7@llnl.gov
Date: February 18, 2010

Distribution: IDCA project file, SSST file, IDCA team members (Indian Head, Tyndall, LANL, SNL)

Sample: RDX was provided by Indian Head and was dried at 60 C for 16 hours, cooled and kept in a desiccator before use.

Please note that the impact testing was done on both pellets and loose powder which resulted in different data. The impact test data on the loose powder was similar to what Indian Head and LANL got. Remarkable consistent results were observed for test results of loose powder RDX. The average impact sensitivity (DH_{50}) was 21.5 cm and the average friction sensitivity (F_{50}) for loose powder was 26.9 kg, respectively. DSC charts showed that peak temperatures and onset temperatures for all 3 runs of RDX samples were almost identical. All electrostatic spark sensitivity was 0/10 @ 1.0 J with a 510-ohm resistor in the discharge circuit.

Impact Test Result Summary for RDX

Sample ID	Test Date	Temperature, F	Relative Humidity (RH), %	Height for 50% Reaction (DH_{50}), cm	Standard Deviation (σ), log unit
RDX (IH), 15089, pellets	11/19/09	75	18	32.3 (29.3-35.6)	0.042
RDX (IH), 15089, loose powder	2/8/10	74	22	21.5 (20.8-22.3)	0.015
RDX (IH), 15089, loose powder	2/16/10	73	23	21.4 (19.8-23.2)	0.035

Friction Test Result Summary for RDX

Sample ID	Test Date	Temp., F	Relative Humidity (RH), %	Friction Reaction (TIL)* 0/10 @ kg	Friction Reaction 1/10 @ kg	Load for 50% Reaction (F_{50}), kg	Standard Deviation (σ), log unit
RDX (IH), 15089	11/23/09	73	18	19.2	21.6	29.2 (25.8-33.1)	0.054
RDX (IH), 15089	2/9/10	73	23	21.6	24.0	27.8 (25.0-30.9)	0.046
RDX (IH), 15089	2/16/10	73	30	16.8	19.2	23.6 (20.1-27.8)	0.070

- TIL- Threshold initiation is the load (kg) at which zero reaction out of ten trials with at least one reaction out of ten trials at the next higher load level.

Static Spark Test Result Summary for RDX

Sample ID	Test Date	Temperature, F	Relative Humidity (RH), %	Spark Reaction* 0/10 @
RDX (IH), 15089	11/18/09	73	18	1.0 Joule
RDX (IH), 15089	2/8/10	73	23	1.0 Joule
RDX (IH), 15089	2/16/10	73	30	1.0 Joule

* With a 510 ohms resistor in the discharge circuit.

DSC Test Result Summary for RDX

Sample ID	Test Date	DSC Onset/Peak Temperature, F Closed Hermetic Pan, C	DSC Onset/Peak Temperature, F Pinhole Hermetic Pan, C
RDX (IH), 15089	12/01/09	205/233.5	203/241.8
RDX (IH), 15089	02/04/10	205/235.6	203/240.7
RDX (IH), 15089	02/04/10	203/233.7	203/241.5

Impact (drop hammer) Test Worksheet

Test Date: 11/19/09

Sample description: RDX (Indian Head) standard, first test of first series

ID Number: 15089

Temperature: 75 F Relative humidity: 18%

Table 1: Impact test for determining the height for 50% reaction

Height, cm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	∑X	∑O
25.0									O		O		O				
28.1				O		O		X		X		X		O			
31.5	O		X		X		X								O		
35.4		X															

Total: 7 8

* X- reaction indicated by voltmeter reading ≥ 1.3 V
O- no reaction indicated by voltmeter reading < 1.3 V

G. H.

Gary Hust
Operator

Peter C. Hsu

Peter C. Hsu
RI for impact test

DROP HAMMER TEST REPORT

Operator:	Gary Hust	
Reviewed and approved by:	Peter Hsu	PSH
Date of Test:	11/19/09	

Name of Explosive:	RDX	IDCA
Identification Number:	15089	
Composition:		

Requester:	Peter Hsu
Project No:	30532
Task No:	2.1.3
Sample Description:	35 mg Pellets
Test Type:	12 A
Temperature:	75 °F
Humidity:	18%
Book Reference:	22-155

Number of X's	7	
Number of O's	8	
+/- 0.5	0.5	
Least Height for X's or O's	28.1	
LOG of Least Height	1.4487	
LOG of Interval	0.05	
# of Events at Least Height	3	28.1
# of Events at Next Height	3	31.5
# of Events at Next Height	1	35.4
# of Events at Next Height	0	39.7
# of Events at Next Height	0	44.5
# of Events at Next Height	0	50.0

Dh_{50} CALCULATION

REMARKS:

Sum (N_i * i)	5	
Sum of Events for Calculation	7	
LOG of Dh_{50}	1.5094	
Dh_{50}		**32.3 cm**

STANDARD DEVIATION CALCULATION

Sum (N_i * i^2)	7	
STANDARD DEVIATION		**0.042**
MAXIMUM Dh_{50}	3.3	**35.6 cm**
MINIMUM Dh_{50}	-3.0	**29.3 cm**

srw

RDX.111909DH.xls

Friction Test Worksheet

Test Date: 11/23/09

Sample description: RDX (Indian Head) standard, first test of first series

ID Number: 15089

Temperature: 73 F Relative humidity: 18%

Table 1: Friction test for determining the load for threshold reaction

Load, kg	1	2	3	4	5	6	7	8	9	10	# of reaction
25.2	X	X									2 of 2
24.0	O	O	X	O	O	O	O	O	O	X	2 of 10
21.6	O	O	O	X	O	O	O	O	O	O	1 of 10
19.2	O	O	O	O	O	O	O	O	O	O	0 of 10

* X- reaction, O- no reaction

Table 2: Friction test for determining the load for 50% reaction

Load, kg	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	∑X	∑O
21.6	O				O		O		O		O						
25.2		O		X		X		X		X		O					
28.8			X										O		X		
32.4														X			

Total: 7 8

G. H.

Gary Hust
Operator

Peter C. Hsu

Peter C. Hsu
RI for friction test

FRICTION TEST REPORT					
Operator:	Gary Hust	Test date:	11/23/09		
Reviewed and approved by:	Peter Hsu	PSH			
Requester:					
Project No:	30532	Book Reference:			
Task No:	2.1.3				
Material:	Dried RDX from Indian Head				
Identification Number:	15089				
Composition:	RDX, 90%, HMX, 10%				
Temperature:	73 F				
Relative Humidity:	18%				
Test Results:	1/10 @ 21.6 kg				
Number of X's	7		Datasheet		
Number of O's	8		Weight	Go (X)	No Go (O)
+/- 0.5	0.5		21.6		O
Least Friction Weight for X's or O's	25.2		25.2		O
LOG of Least Friction Weight	1.4014		28.8	X	
LOG of Interval	0.06		25.2	X	
	# of Events	Wt, kg	21.6		O
# of Events at Least Weight	4	25.2	25.2	X	
# of Events at Next Weight	2	28.8	21.6		O
# of Events at Next Weight	1	32.4	25.2	X	
# of Events at Next Weight	0	37.2	21.6		O
# of Events at Next Weight	0	42.7	25.2	X	
# of Events at Next Weight	0	49.0	21.6		O
			25.2		O
Dh_{50} CALCULATION			28.8		O
			32.4	X	
Sum (N_i * i)	4		28.8	X	
Sum of Events for Calculation	7		Total	7	8
LOG of F_{50}	1.4657				
F_{50}		**29.2**	**Kg**		
NDARD DEVIATION CALCULATION					
Sum (N_i * i^2)	6				
STANDARD DEVIATION		**0.054**			
MAXIMUM F_{50}	3.9	**33.1**	**Kg**		
MINIMUM F_{50}	-3.4	**25.8**	**Kg**		

srw

RDX_1.1-up&dn.xls

ELECTROSTATIC SPARK TEST REPORT

Operator: Gary Hust G.H. Test Date: 11/18/09

Reviewed and Approved by : Peter Hsu Peter Hsu

Requestor: Peter Hsu

Project No: 30532

Task No: 2.1.3

Temp: 73 °F

Material: RDX IDCA

R.H: 18%

ID Number: 15089

Composition:

CAP. (pF)	VOLTS (kV)	RESISTANCE (ohms)	GAP (in.)	ENERGY (Joules)	REACTION (YES or NO)
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO

0 OF 10 TESTS @ 1.0 JOULES WITH 510-OHM RESISTANCE

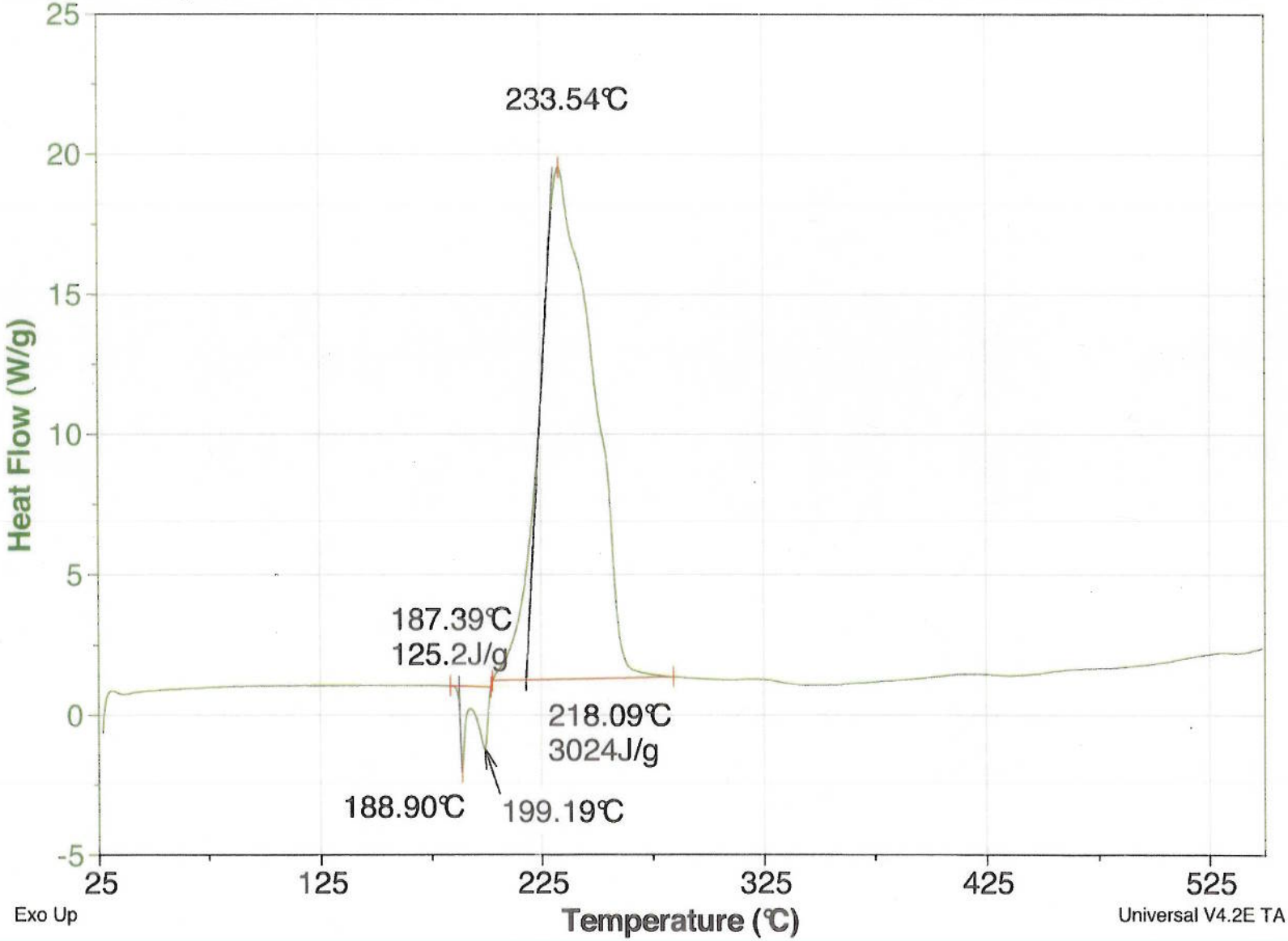
_____ IS SPARK SENSITIVE ___X___ IS NOT SPARK SENSITIVE

REMARKS:

Sample: RDX #15089
Size: 0.3160 mg
Method: RT to 550 @ 10cpm
Comment: Hsu_ Closed Hermetic Pan

DSC

File: MM09-1245.001
Operator: TURNER
Run Date: 01-Dec-2009 12:54
Instrument: 2920 MDSC V2.6A

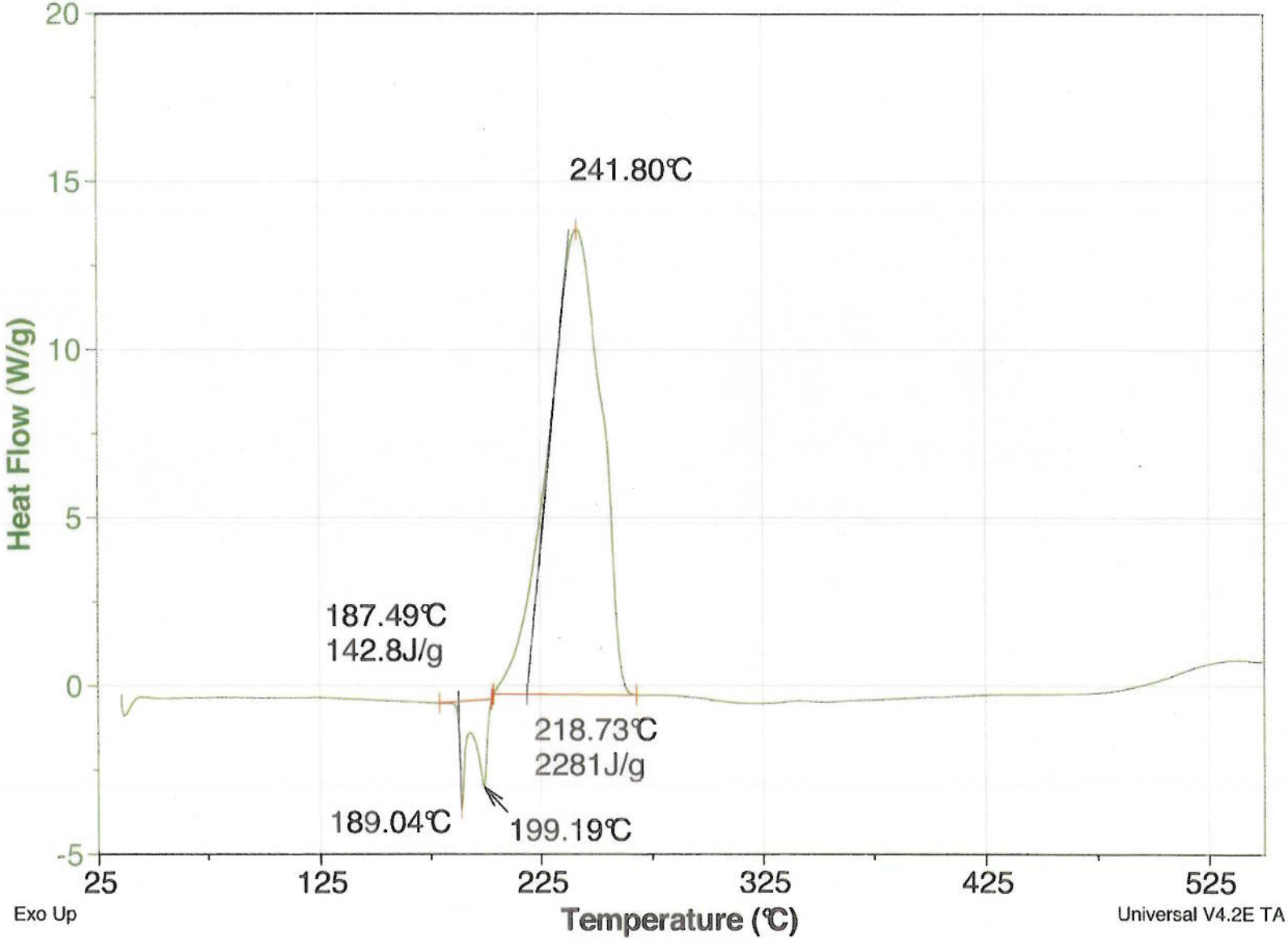


Universal V4.2E TA Instruments

Sample: RDX #15089
Size: 0.3300 mg
Method: RT to 550 @ 10cpm
Comment: Hsu_ Pinhole Hermetic Pan

DSC

File: MM09-1247.001
Operator: TURNER
Run Date: 01-Dec-2009 14:31
Instrument: 2920 MDSC V2.6A



Exo Up

Universal V4.2E TA Instruments

Impact (drop hammer) Test Worksheet

Test Date: 02/08/10

Sample description: RDX (Indian Head) standard, second test of first series

ID Number: 15089

Temperature: 74 F Relative humidity: 22%

Table 1: Impact test for determining the height for 50% reaction

Height, cm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	∑X	∑O
22.3								O		O		O		O			
25.0					O		X		X		X		X		X		
28.1				X		X											
31.5			X														
35.4		X															
39.7	X																

Total: 7 8

* X- reaction indicated by voltmeter reading ≥ 1.3 V
O- no reaction indicated by voltmeter reading < 1.3 V

G. H.

Gary Hust
Operator

Peter C. Hsu

Peter C. Hsu
RI for impact test

DROP HAMMER TEST REPORT

Operator:	Gary Hust G.H.
Reviewed and approved by:	Peter Hsu PSH
Date of Test:	2/8/10

Name of Explosive:	RDX	IDCA
Identification Number:	15089	
Composition:	RDX 90%, HMX, 10%	
	second test of first series	
Requester:	Peter Hsu	
Project No:	30458	
Task No:	108225	
Sample Description:	35 mg Powder	
Test Type:	12 A	
Temperature:	74 °F	
Humidity:	22%	
Book Reference:	23-18	

Number of X's	10	
Number of O's	5	
+/- 0.5	-0.5	
Least Height for X's or O's	22.3	
LOG of Least Height	1.3483	
LOG of Interval	0.05	
# of Events at Least Height	4	22.3
# of Events at Next Height	1	25.0
# of Events at Next Height	0	28.1
# of Events at Next Height	0	31.5
# of Events at Next Height	0	35.3
# of Events at Next Height	0	39.7

Dh_{50} CALCULATION

REMARKS:

Sum (N_i * i)	1	
Sum of Events for Calculation	5	
LOG of Dh_{50}	1.3333	
Dh_{50}		**21.5 cm**

STANDARD DEVIATION CALCULATION

Sum (N_i * i^2)	1	
STANDARD DEVIATION		**0.015**
MAXIMUM Dh_{50}	0.8	**22.3 cm**
MINIMUM Dh_{50}	-0.7	**20.8 cm**

srw

RDX(IH)-1.2-DH.xls

Friction Test Worksheet

Test Date: 02/09/10

Sample description: RDX (Indian Head) Standard, second test of first series
ID Number: 15089

Temperature: 73 F Relative humidity: 23%

Table 1: Friction test for determining the load for threshold reaction

Load, kg	1	2	3	4	5	6	7	8	9	10	# of reaction
24.0	X	0	0	0	0	0	0	0	0	0	1 of 10
21.6	0	0	0	0	0	0	0	0	0	0	0 of 10

* X- reaction, 0- no reaction

G.H.

Gary Hust
Operator

Peter C. Hsu

Peter C. Hsu
RI for friction test

FRICTION TEST REPORT					
Operator:	Gary Hust G.H	Test date:	2/9/10		
Reviewed and approved by:	Peter Hsu PSH				
Requester:	Peter Hsu				
Project No:	30458	Book Reference:	3-68		
Task:	108225				
Material:	Dried RDX from Indian Head				
Identification Number:					
Composition:	RDX, 90%, HMX, 10%				
Temperature:	73°F				
Relative Humidity:	23%				
Test Results: 1of10	1/10 @ 24.0 kg		Datasheet		
Test Results: 0of10	0/10 @ 21.6 Kg		Weight	Go (X)	No Go (O)
			25.2		O
Number of X's	9		28.8	X	
Number of O's	9		25.2	X	
+/- 0.5	0.5		21.6		O
Least Friction Weight for X's or O's	21.6		25.2		O
LOG of Least Friction Weight	1.3345		28.8	X	
LOG of Interval	0.06		25.2		O
	# of Events	Wt, kg	28.8	X	
# of Events at Least Weight	1	21.6	25.2	X	
# of Events at Next Weight	4	25.2	21.6		O
# of Events at Next Weight	4	28.8	25.2	X	
# of Events at Next Weight	0	32.4	21.6	X	
# of Events at Next Weight	0	36.0	19.2		O
# of Events at Next Weight			21.6		O
			25.2	X	
Dh_{50} CALCULATION			21.6		O
			25.2		O
Sum (N_i * i)	12		28.8	X	
Sum of Events for Calculation	9		Total	9	9
LOG of F_{50}	1.4445				
F_{50}		**27.8**	**Kg**		
NDARD DEVIATION CALCULATION					
Sum (N_i * i^2)	20				
STANDARD DEVIATION		**0.046**			
MAXIMUM F_{50}	3.1	**30.9**	**Kg**		
MINIMUM F_{50}	-2.8	**25.0**	**Kg**		

ELECTROSTATIC SPARK TEST REPORT

Operator: Gary Hust G.H.

Test Date: 2/8/10

Reviewed and Approved by : Peter Hsu PSH

Requestor: Peter Hsu

Project No: 30458 IDCA

Task No: 108225

Temp: 73 °F

Material: RDX
second test of first series

R.H: 23%

ID Number: 15089

Composition: RDX 90%, HMX 10%

CAP. (pF)	VOLTS (kV)	RESISTANCE (ohms)	GAP (in.)	ENERGY (Joules)	REACTION (YES or NO)
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO

0 OF 10 TESTS @ 1.0 JOULES WITH 510-OHM RESISTANCE

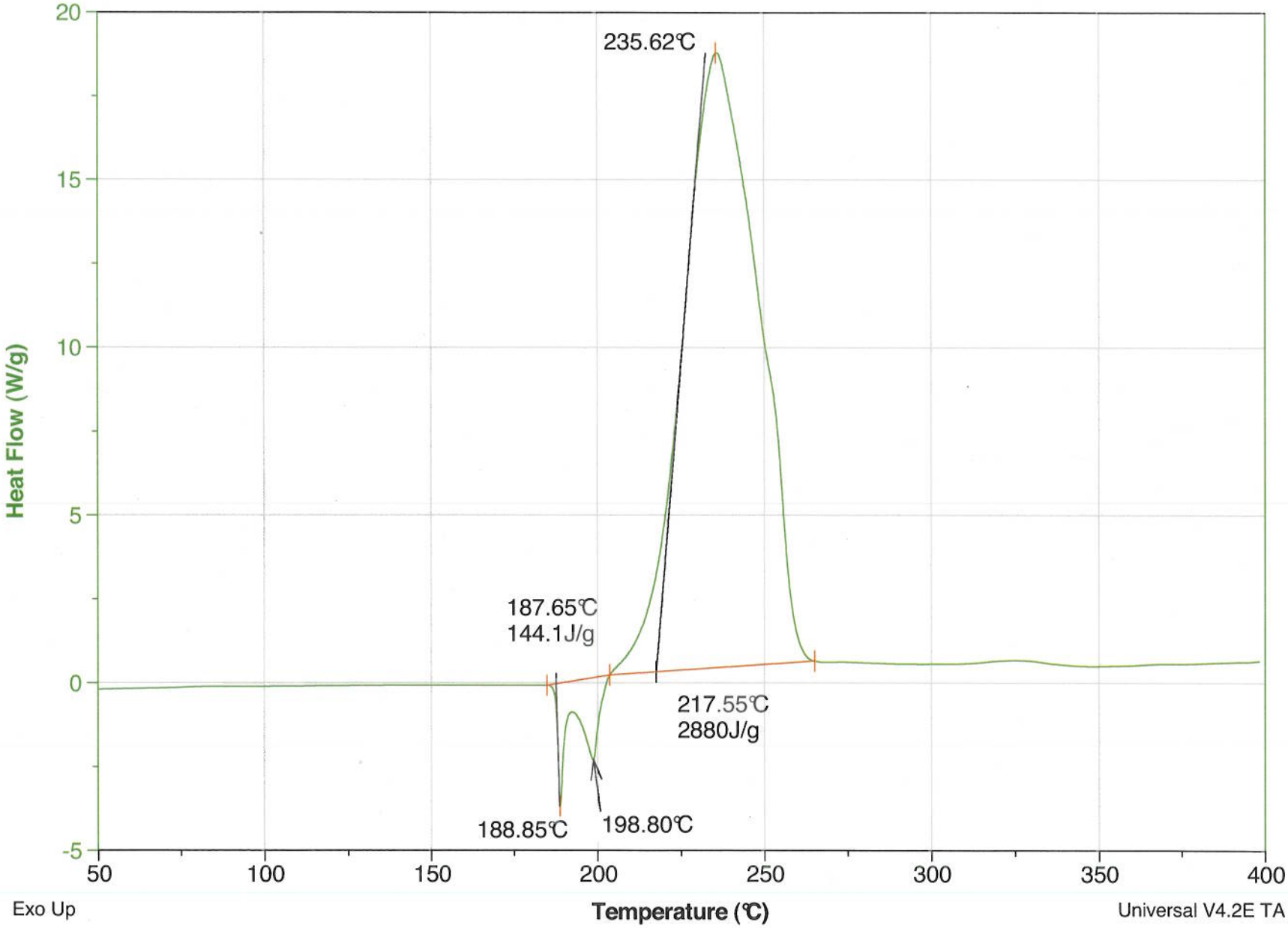
_____ IS SPARK SENSITIVE ___X___IS NOT SPARK SENSITIVE

REMARKS:

Sample: RDX #15089
Size: 0.2500 mg
Method: RT to 400@ 10cpm
Comment: Hsu_ Closed hermetic pan

DSC

File: M10-093.001
Operator: TURNER
Run Date: 05-Feb-2010 09:01
Instrument: 2920 MDSC V2.4F



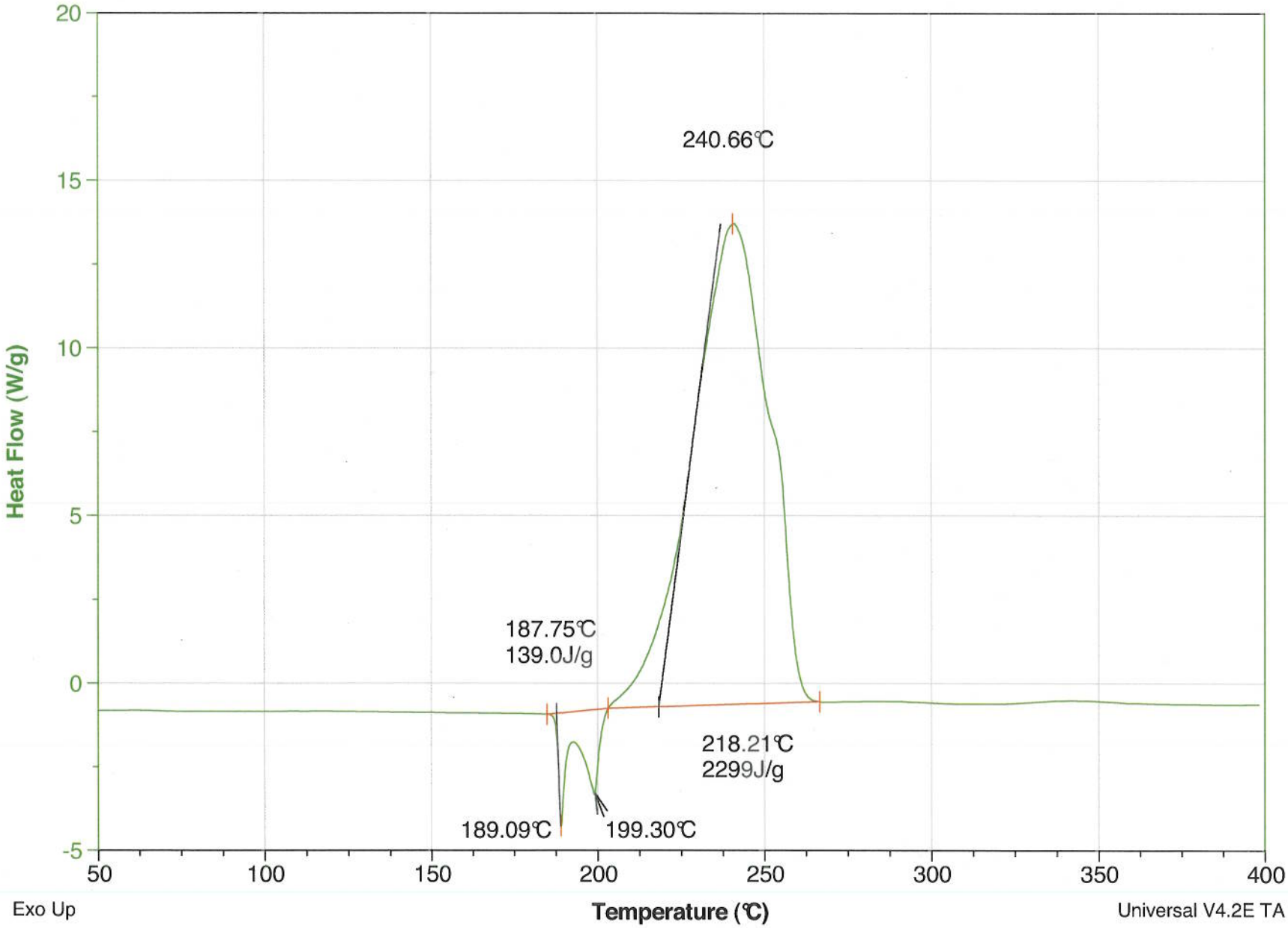
Exo Up

Universal V4.2E TA Instruments

Sample: RDX #15089
Size: 0.3480 mg
Method: RT to 400@ 10cpm
Comment: Hsu_ Pinhole hermetic

DSC

File: M10-089.001
Operator: TURNER
Run Date: 04-Feb-2010 15:36
Instrument: 2920 MDSC V2.4F



Exo Up

Universal V4.2E TA Instruments

Impact (drop hammer) Test Worksheet

Test Date: 02/16/10

Sample description: RDX (Indian Head) standard, third test of first series

ID Number: 15089

Temperature: 73 F Relative humidity: 23%

Table 1: Impact test for determining the height for 50% reaction

Height, cm	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	∑X	∑O
19.9											O						
22.3		O				O		O		X		O					
25.0	X		O		X		X		X				O		X		
28.1				X										X			
31.5																	
35.4																	
39.7																	

Total: 8 7

* X- reaction indicated by voltmeter reading ≥ 1.3 V
O- no reaction indicated by voltmeter reading < 1.3 V

G.H.

Gary Hust
Operator

Peter C. Hsu

Peter C. Hsu
RI for impact test

DROP HAMMER TEST REPORT

Operator:	Gary Hust G.H.
Reviewed and approved by:	Peter Hsu P.H
Date of Test:	2/16/10
Name of Explosive:	RDX
Identification Number:	15089
Composition:	RDX 90%, HMX 10%
Requester:	Peter Hsu
Project No:	30458
Task No:	108225
Sample Description:	35 mg Powder
Test Type:	12 A
Temperature:	73 °F
Humidity:	27%
Book Reference:	23-19

Number of X's	8	
Number of O's	7	
+/- 0.5	-0.5	
Least Height for X's or O's	19.9	
LOG of Least Height	1.2989	
LOG of Interval	0.05	
# of Events at Least Height	1	19.9
# of Events at Next Height	4	22.3
# of Events at Next Height	2	25.1
# of Events at Next Height	0	28.1
# of Events at Next Height	0	31.5
# of Events at Next Height	0	35.4

Dh_{50} CALCULATION

REMARKS:

Sum (N_i * i)	8	
Sum of Events for Calculation	7	
LOG of Dh_{50}	1.3310	
Dh_{50}		**21.4 cm**

STANDARD DEVIATION CALCULATION

Sum (N_i * i^2)	12	
STANDARD DEVIATION		**0.035**
MAXIMUM Dh_{50}	1.8	**23.2 cm**
MINIMUM Dh_{50}	-1.7	**19.8 cm**

Friction Test Worksheet

Test Date: 02/16/10

Sample description: RDX (Indian Head) standard, third test of first series
ID Number: 15089

Temperature: 73 F Relative humidity: 30%

Table 1: Friction test for determining the load for threshold reaction

Load, kg	1	2	3	4	5	6	7	8	9	10	# of reaction
21.6	O	O	X	O	O	X					2 of 6
19.2	O	O	O	O	O	O	O	O	O	X	1 of 10
16.8	O	O	O	O	O	O	O	O	O	O	0 of 10

* X- reaction, O- no reaction

G. H.

Gary Hust
Operator

Peter C. Hsu

Peter C. Hsu
RI for friction test

FRICTION TEST REPORT					
Operator:	Gary Hust G.H.	Test date:	2/16/10		
Reviewed and approved by:	Peter Hsu				
Requester:	Peter Hsu P.H.				
Project No:	30458	Book Reference:	3-69		
Task:	108225				
Material:	Dried RDX from Indian Head				
	Third test of first series				
Identification Number:	15089				
Composition:	RDX, 90%, HMX, 10%				
Temperature:	73°F				
Relative Humidity:	30%				
Test Results: 1of10	1/10 @ 19.2 kg		Datasheet		
Test Results: 0of10	0/10 @ 16.8 Kg		Weight	Go (X)	No Go (O)
			28.8	X	
Number of X's	8		25.2	X	
Number of O's	7		21.6		O
+/- 0.5	-0.5		25.2	X	
Least Friction Weight for X's or O's	21.6		21.6		O
LOG of Least Friction Weight	1.3345		25.2	X	
LOG of Interval	0.06		21.6		O
	# of Events	Wt, kg	25.2		O
# of Events at Least Weight	3	21.6	28.8		O
# of Events at Next Weight	2	25.2	32.4	X	
# of Events at Next Weight	3	28.8	28.8		O
# of Events at Next Weight	0	36.0	32.4	X	
# of Events at Next Weight	0		28.8	X	
# of Events at Next Weight			25.2		O
			28.8	X	
Dh_{50} CALCULATION			Total	8	7
Sum (N_i * i)	8				
Sum of Events for Calculation	7				
LOG of F_{50}	1.3730				
F_{50}		**23.6**	**Kg**		
NDARD DEVIATION CALCULATION					
Sum (N_i * i^2)	14				
STANDARD DEVIATION		**0.070**			
MAXIMUM F_{50}	4.1	**27.8**	**Kg**		
MINIMUM F_{50}	-3.5	**20.1**	**Kg**		

ELECTROSTATIC SPARK TEST REPORT

Operator: Gary Hust G.H. Test Date: 2/16/10

Reviewed and Approved by : Peter Hsu PSH

Requestor: Peter Hsu

Project No: 30458 IDCA

Task No: 108225

Temp: 73 °F

Material: RDX
third test of first series R.H: 30%

ID Number: 15089

Composition: RDX 90%, HMX 10%

CAP. (pF)	VOLTS (kV)	RESISTANCE (ohms)	GAP (in.)	ENERGY (Joules)	REACTION (YES or NO)
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO
20K	10	510	.007	1.00	NO

0 OF 10 TESTS @ 1.0 JOULES WITH 510-OHM RESISTANCE

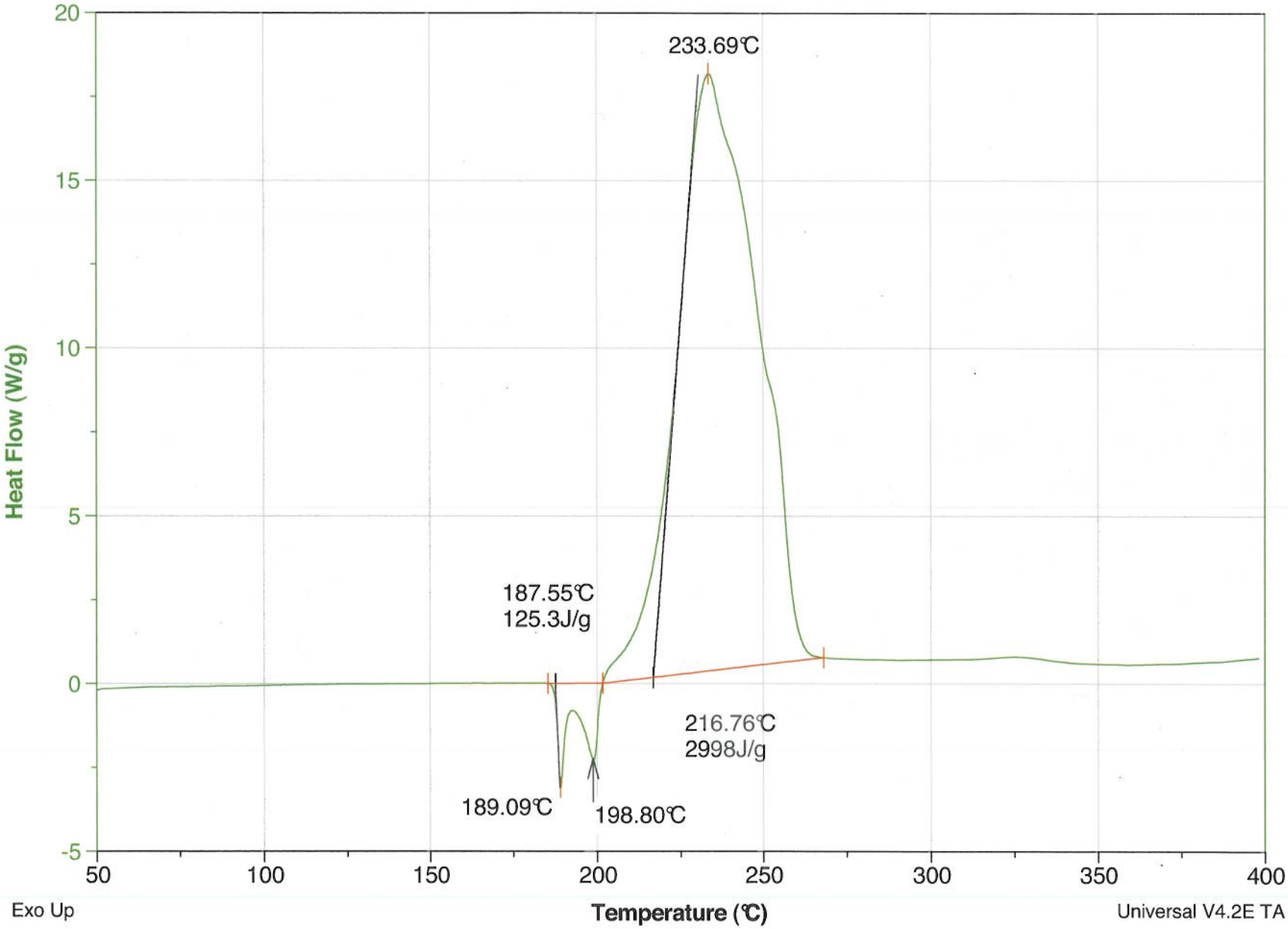
_____ IS SPARK SENSITIVE ___X___ IS NOT SPARK SENSITIVE

REMARKS:

Sample: RDX #15089
Size: 0.2500 mg
Method: RT to 400@ 10cpm
Comment: Hsu_ Closed hermetic

DSC

File: M10-086.001
Operator: TURNER
Run Date: 04-Feb-2010 10:36
Instrument: 2920 MDSC V2.4F



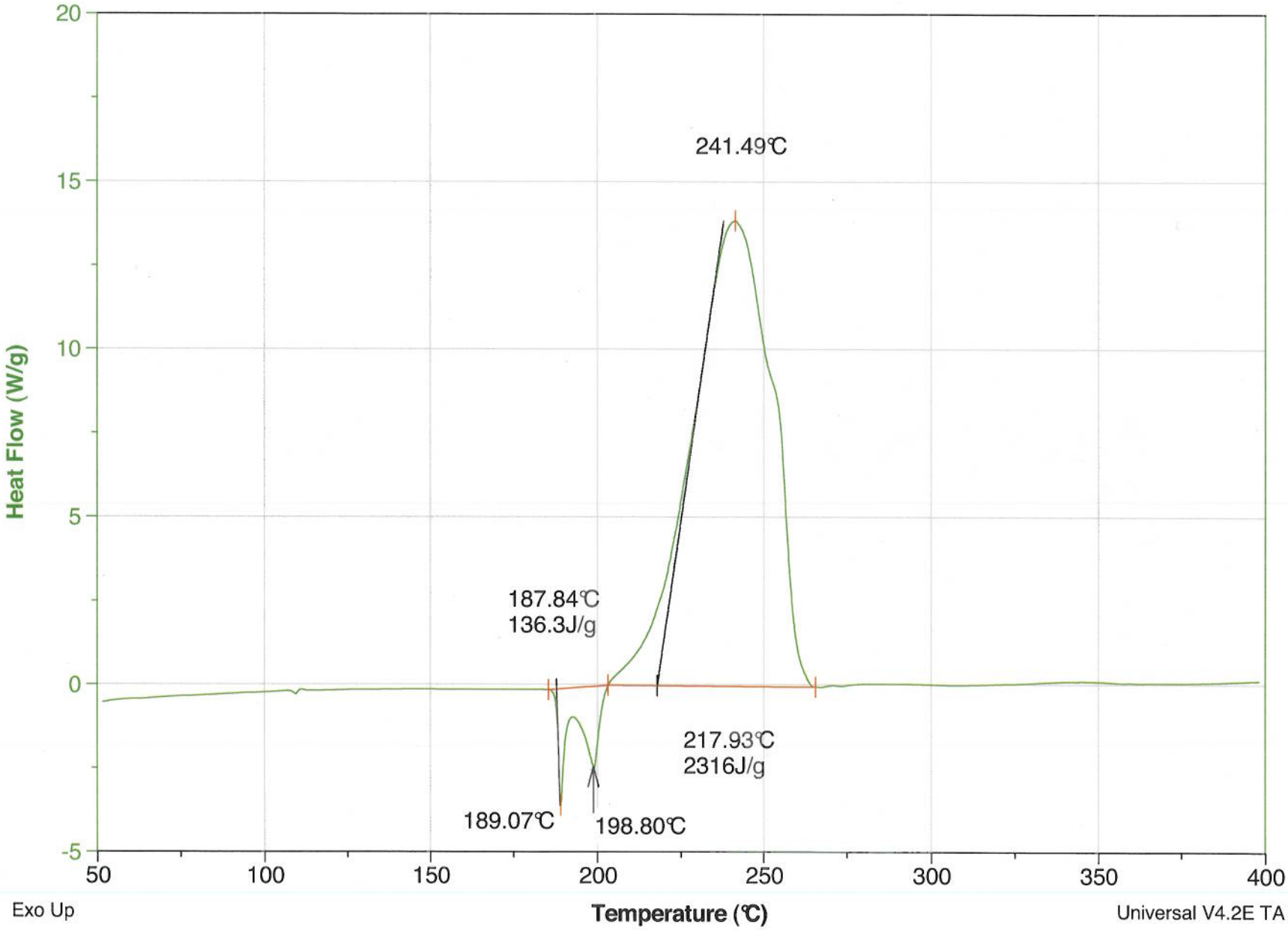
Exo Up

Universal V4.2E TA Instruments

Sample: RDX #15089
Size: 0.3500 mg
Method: RT to 400@ 10cpm
Comment: Hsu_ Pinhole hermetic pan

DSC

File: M10-095.001
Operator: TURNER
Run Date: 05-Feb-2010 10:11
Instrument: 2920 MDSC V2.4F



Exo Up

Universal V4.2E TA Instruments