Some Experiments on the Sensitivity of Initial Explosives

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1. Introduction

T. Yanagisawa & the late Professor S. Yamamoto[1] arried out experiments of desensitisation of some explosive conpounds by adding water and gave the standards of maintaining safety in handling explosives concerning their manufacture, storage and transport. Formerly it had only been shown qualitatively. (Fig. 1)

According to their data it was made clear that picric acid (PA) was not dangerous when it contained above 15 % of water and that penthrit (PETN) was not desensitised merely by adding water to it.

The present investigation was extended to some initial explosives and was carried out, from the same point of view of maintaining safety, to find the relations between water content and impact, friction and Hess initiaion sensitivities.

The impact sensitivity of initial explosives as well as that of secondary explosives has been measured by Fall Hammer Test which was decided at 8th International Applied Chemistry Congress at Washington, 1912, but such a test is not enough to find differences of sensitivity among initial explosives. And so a useful impact sensitivity apparatus was made for the purpose of this wrok.

The results of this wrok showed that diazodinitro-phenol (DDNP) was very insensitive compared with mercury fulminate which had

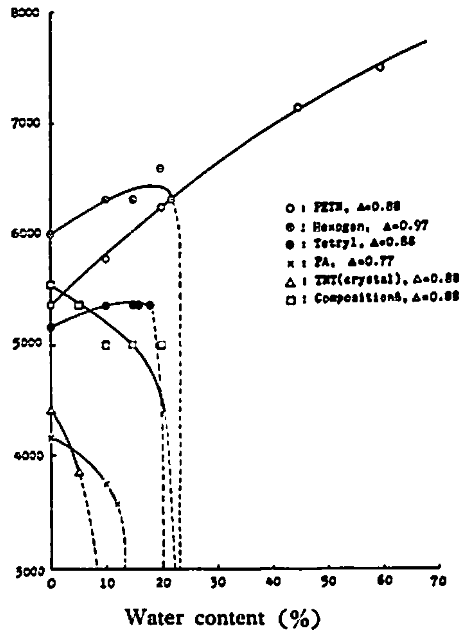

Fig 1. The effect of water content on the detonation velocity of secondary explosive's compounds. Enclosure; vinyl, 17mm in inner diameter, 1mm in thickness. Initation; No. 6 electric detonator. Measurement; by electronic counter, 3cm apart from the base of detonator (T. Yanagisawa, S. Yamamoto)

been formerly used as commercial initial explosives and that percussion's priming materials and its main constituent lead styphnate were capable of abrupt desensitisation by having a small percentage of water added to them.

2. Impact Sensitivity

(1) Apparatus of Experiment

A sketch of the apparatus used for measuring the impact sensitivity is shown in Fig. 2. This is a slight modification of the app-

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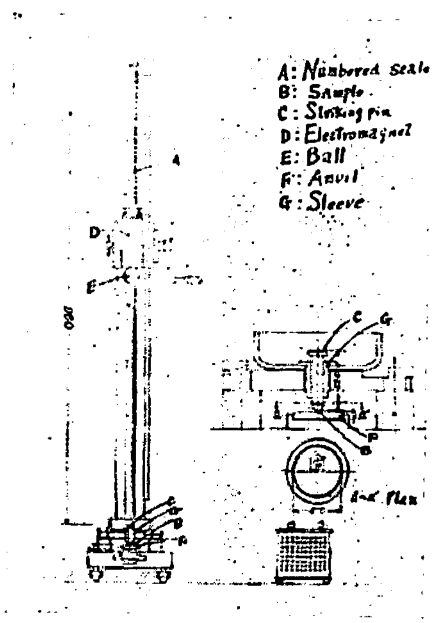

Fig. 2 Sketch of the impact sensitivity apparatus

aratus used by M. P. Murgai & A. K. Ray[2] for studying the impact sensitivity of mercury fulminate. The assembly of striking pin, sleeve & anvil is a little modified to be convenient to use.

The height of the steel ball, which is 37.7 mm in diameter and 130.2 g in weight, can be adjusted by sliding the electromagnet along the vertical rod.

The pole-piece of the electromagnet is made concave so that the striking balls will fit exactly in the same position every time. The central position of the striking pin head and the pole of the concave electromagnet are always kept in the same vertical line.

The striking pin is made of steel; 10 mm in dia., 46.4mm in length, 29.9g in weight, 0.246 cm^2 in contact surface area with sample (5.6 mm in dia.). About 5 mg of samples are weighed by chemical balance. The anvil is made of steel; 40 mm in dia., 6 mm in thickness, 55 in Brinell Hardness.

(2) Experimental Procedure

The experiments were carried out by applying the up & down method by W. J. Dixon & A. M. Mood[3]

Sample size N=40 is randomised at every time and 50% explosion efficient heights (H) are obtained. At semilar water content they are repeated 3 times.

Mean value & standard deviation are found as follows:

Moment

$$A=\sum ini, \quad B=\sum i^2ni$$

ni= Frequencies at each level i

Mean value

$$m=y+d\left(\frac{A}{N}\pm\frac{1}{2}\right), \quad N=\sum ni$$

y : The normalised height corresponding to lowest level on which the less frequent event occurs.

d : Level intervals

$\pm$: The plus sign is used when the analysis based on th failures and the minus sigh when it is based on the successes which include the partial explosions into account.

The estimation of sample's standard deviation

$$\sigma=1.620\,d\left(\frac{NB-A^2}{N_2}+0.029\right)$$

(3) Experimental Results

Table 1. The effect of water content on the impact sensitivity of various initial explosives.

Explosive	Experimental order no.	Water content, W (%)	50% explosion height (mm) Mean value H	Deviation σ
DDNP (granular crystal) Δ=0.557	1	0.53	290	36.1
	2	0.71	254	33.1
	3	0.72	268	74.1
	1	2.81	403	114.2
	2	2.92	407	72.9
	3	2.69	403	80.3

Explosive	Experimental order no.	Water content. W (%)	50% explosion height (mm) Mean value H	Deviation σ
DDNP (granular crystal) $\Delta=0.557$	1	8.51	605	44.6
	2	8.47	782	54.5
	3	8.06	758	58.5
	1	10.34	7/20*	—
	2	10.41	709	48.7
	3	10.23	4/20*	—
	1	14.87	1/20*	—
	2	14.92	0/20*	—
	3	14.76	0/20*	—
	1	17.50	0/20*	—
DDNP (granular crystal) $\Delta=0.427$	1	0.18	271	49.4
	2	0.43	350	11.8
	3	0.64	227	22.1
	1	1.45	292	35.3
	2	0.64	255	158.4
	3	0.85	314	78.2
	1	4.74	85	223.4
	2	3.39	358	46.9
	3	3.28	546	73.6
	1	9.33	1/20*	—
	2	7.77	632	48.3
	3	8.13	753	6.9
	1	13.02	1/20*	—
	2	15.44	8/20*	—
	3	11.65	6/20*	—
	1	17.06	0/20*	—
	2	15.61	2/20*	—
	3	15.97	0/20*	—
	1	20.21	0/20*	—
	2	19.59	0/20*	—
DDNP (needle crystal) $\Delta=0.316$	1	0.18	143	54.3
	2	0.31	234	77.4
	3	0.18	215	60.2
	1	0.82	148	105.2
	2	0.97	234	110.1
	3	0.87	271	47.3
	1	4.42	178	239.4
	2	5.00	304	52.2
	3	3.87	417	46.6

Explosive	Experimental order no.	Water content. W (%)	50% explosion height (mm) Mean value H	Deviation σ
DDNP (needle crystal) $\Delta=0.316$	1	11.78	581	82.4
	2	11.12	470	112.0
	3	9.94	638	77.9
	1	14.20	627	56.2
	2	14.94	643	80.3
	3	14.47	895	71.1
	1	18.58	3/20*	—
	2	18.65	6/20*	—
	3	18.43	4/20*	—
	1	23.21	0/20*	—
	2	23.70	0/20*	—
	3	24.54	0/20*	—
Mercury fulminate $\Delta=1.49$	1	0.02	4.4	1.90
	2	0.12	3.8	1.67
	3	0.01	4.7	2.84
	1	2.55	10.1	3.16
	2	2.77	8.0	3.10
	3	2.44	9.4	3.63
	1	5.83	11.9	3.81
	2	5.41	12.7	5.01
	3	5.27	13.2	0.41
	1	9.68	14.1	3.99
	2	9.25	14.7	5.38
	3	8.98	13.9	6.11
	1	14.44	15.4	4.37
	2	14.16	10.7	1.71
	3	14.30	14.2	5.84
	1	19.57	18.0	4.02
	2	19.10	15.4	10.09
	3	19.55	13.1	2.96
Lead styphnate	1	0.49	1.7	2.04
	2	2.13	2.6	0.92
	1	0.50	2.5	2.83
	2	5.63	8.7	10.35
	3	0.48	2.4	1.74
	1	2.67	3.5	4.29
	2	7.83	10.4	2.69
	3	0.49	1.5	0.84
	1	6.39	10.1	3.48
	2	9.94	12.5	6.19
	3	1.63	2.7	2.23

Explosive	Experimental order No.	Water content, W (%)	50% explosion height (mm)	
			Mean value H	Deviation σ
Lead styphnate	1	10.20	11.4	4.73
	2	11.22	19.2	3.64
	3	5.61	11.0	7.05
	1	13.48	14.6	2.82
	2	18.82	21.7	9.47
	3	8.98	11.3	8.70
	1	15.14	28.1	14.15
	2	20.22	18.5	60.50
	3	12.65	26.8	5.18
Percussion's priming materials	1	0.71	10.4	15.40
	1	0.87	7.4	6.38
	1	6.10	0/20*	—
	2	1.52	6.9	3.89
	3	0.69	6.8	2.48
	4	0.87	7.3	2.76
	2	1.76	7.7	4.72
	3	0.80	7.2	4.20
	4	1.43	7.2	3.23
	2	2.53	6.8	2.72
	3	0.83	7.2	1.51
	4	2.21	6.7	3.13
	2	4.59	10.0	7.75
	3	4.25	15.6	10.08
	4	4.45	27.8	13.00
	2	5.98	6.1	3.03
	3	6.02	7/20*	—
	4	6.46	27.2	12.00
	2	8.03	12/20*	—
	3	7.48	4/20*	—
	4	8.54	18/20*	—
	2	9.77	0/20*	—
	3	9.99	0/20*	—
	4	10.31	14/20*	—

* Explosion's probability sample size=20 at maximum height=924mm

DDNP is linearly desensitised as its water content increases. The between water content (W) & 50% explosion height (H) are given as follows:

H=252.03+51.5oW for granular crystal,

Δ=0.557

H=266.00+61.09W for granular crystal,

Δ=0.427

H=168.90+36.59W for needle crystal,

Δ=0.316

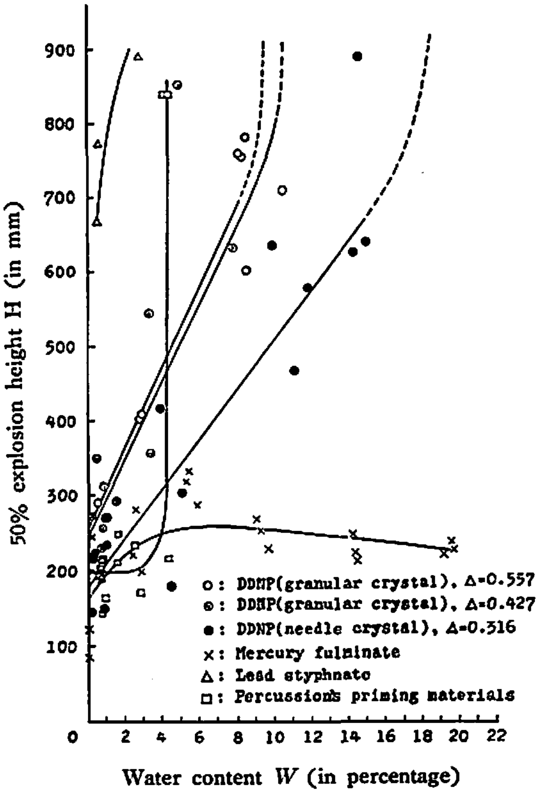

Fig. 3 The effect of water content on the impact sensitivity of various initial explosives

Among the three kinds of DDNP the needle crystal (bulk density Δ=0.316) is the most sensitive compared with other granular crystals and the granular crystal seems to be slightly more sensitive at a higher density (Δ=0.557) than at a lower density (Δ=0.427).

Mercury fulminate is very sensitive in a dry state and it is remarkable that its sensitivity is almost maintained even when it contains 20% of water.

Percussion's priming materials are composed of lead styphnate (44.3%), tetracene (2.5%)

barium nitrate (46.2%), and metallic fine powder (7%). They are abruptly desensitised by adding a small percentage of water and are become remarkably insensitive when 5% of water is added.

Lead styphnate which is the main constituent of them is considerably insensitive in a dry state and desensitised by having a small percentage of water added.

The specific surface area and mean particle diameter of samples was measured by air permeability method.[4] The results are given in Table 2.

Table 2

Sample	DDNP						Mercury fulminate		Percussion's priming materials	
	Granulars Δ=0.557		Granulars Δ=0.427		Needles Δ=0.316					
	Obs.	Mean.	Obs.	Mean.	Obs.	Mean.	Obs.	Mean.	Obs.	Mean.
Specific surface area (cm^2/g)	864.3 845.7 857.5	855.8	1,279 1,224 1,255	1,252.7	3,074.4 3,050.4 3,109.6	3,078.1	646.7 652.7 641.3	646.9	484.0 455.2 470.8	470.0
Specific mean particle diameter (μ)	43 44 43	43	29 30 29	29	11 11 11	11	21 21 21	21	48 45 44	44

Such a experiment of the initial explosives seems not to have been carried out yet owing to their dangerous explosion tendency.

3. Friction Sensitivity

Experiments are carried out by Dr. M. Yamada's Friction Test Apparatus[5]. This is commonly used for sensitivity test of initial explosives in Japan.

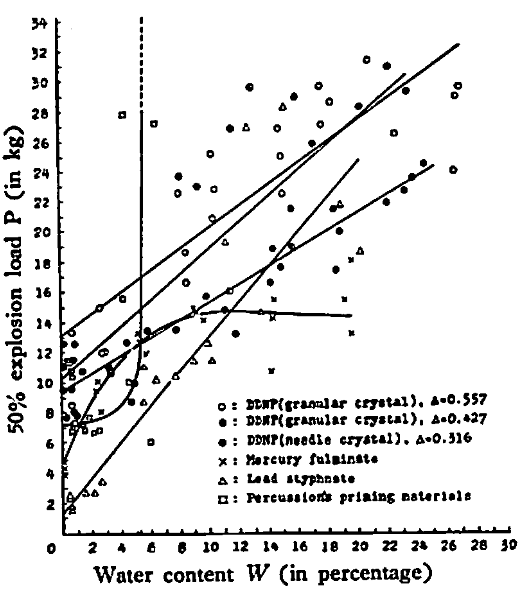

Fig. 4 The effect of water content on the friction sensitivity of various initial explosives

A sample is put between the colundum test pieces, each load given by compressing spring and slidden by pendulum swing.

Samples are used in the same way as in the impact test. Experimental procedure here is, again, the up & down method.

(1) Experimental Results

The experimental results are given in Table 3 & Fig. 4.

Table 3 The effect of water content on the friction sensitivity of various initial explosives.

Explosive	Experimental order no.	Water content. W (%)	50% explosion load (kg)	
			Mean value P	Deviation
DDNP (granular crystal) Δ=0.557	1	0.53	11.3	1.36
	2	0.71	8.5	4.74
	3	0.72	13.4	2.52
	1	2.81	12.0	8.07
	2	2.91	12.0	4.29
	3	2.69	15.1	7.04

Explosive	Experimental order No.	Water content, W (%)	50% explosion load (kg) Mean value P	Deviation
DDNP (granular crystal) Δ=0.557	1	8.51	16.6	5.32
	2	8.47	18.6	17.14
	3	8.06	22.5	8.15
	1	10.34	20.8	8.37
	2	10.41	22.7	3.46
	3	10.23	25.1	7.62
	1	14.87	24.9	6.45
	2	14.92	22.4	5.95
	3	14.76	26.7	2.52
	1	17.57	29.5	3.52
	2	17.70	26.9	6.01
	3	18.26	28.4	5.25
	1	20.79	31.2	7.05
	2	22.50	26.4	2.35
	3	26.54	28.9	3.07
	1	26.54	23.5	7.62
	2	26.80	29.5	3.93
DDNP (granular crystal) Δ=0.427	1	0.18	12.6	3.99
	2	0.43	11.8	5.92
	3	0.64	10.8	5.80
	1	1.45	10.8	3.21
	2	0.64	9.6	3.56
	3	0.85	8.0	3.67
	1	4.74	8.7	2.51
	2	3.39	10.7	4.32
	3	3.28	11.0	6.76
	1	9.33	22.9	5.42
	2	7.77	13.5	7.78
	3	8.13	23.6	11.26
	1	13.02	29.5	5.68
	2	11.54	16.0	5.40
	3	11.65	26.8	8.58
	1	17.06	25.7	4.94
	2	15.61	18.9	6.56
	3	15.97	28.8	8.16
	1	20.21	28.1	10.95
	2	15.59	21.4	2.89
	3	22.04	30.8	4.17
	1	23.26	29.1	9.48
	2	22.20	21.8	8.53

Explosive	Experimental order No.	Water content, W (%)	50% explosion load (kg) Mean value P	Deviation
DDNP (needle crystal) Δ=0.316	1	0.175	11.2	3.62
	2	0.31	7.7	2.18
	3	0.18	9.6	3.38
	1	0.82	11.5	4.55
	2	0.96	7.9	5.98
	3	0.87	12.6	3.81
	1	4.42	12.7	6.00
	2	4.99	9.9	5.33
	3	3.87	13.4	3.28
	1	11.78	13.2	5.37
	2	11.12	14.8	3.44
	3	9.94	15.7	6.29
	1	14.19	16.6	4.61
	2	14.94	17.6	6.53
	3	14.43	18.8	7.84
	1	18.58	17.4	2.66
	2	18.65	19.9	4.82
	3	18.48	21.4	4.61
	1	23.21	22.6	3.55
	2	23.69	23.5	15.50
	3	24.54	24.4	5.91
Mercury fulminate Δ=1.49	1	0.01	120	35.3
	2	0.12	244	67.7
	3	0.02	83	63.0
	1	2.44	219	193.3
	2	2.55	280	113.5
	3	2.77	198	97.1
	1	5.27	318	49.2
	2	5.41	332	40.3
	3	5.83	286	52.3
	1	8.98	268	83.9
	2	9.25	252	39.5
	3	9.68	229	26.4
	1	14.30	224	93.9
	2	14.16	248	31.4
	3	14.44	213	47.2
	1	19.55	240	52.8
	2	19.10	223	63.2
	3	19.57	230	44.5
Lead styphnate	1	0.49	667	118.4
	2	2.13	1/25*	—

Explosive	Experimental order No.	Water content, W (%)	50% explosion load (kg)	
			Mean value P	Deviation
Lead styphnate	1	0.50	772	90.6
	2	5.63	0/20	—
	3	0.43	8/20	—
	1	2.67	890	90.2
	2	7.83	0/20*	—
	3	0.49	10/20*	—
	1	6.39	1/20*	—
	2	9.94	0/20*	—
	3	1.63	6/20*	—
	1	10.20	0/20*	—
	2	11.22	0/20*	—
	3	5.61	0/20*	—
	1	13.48	0/20*	—
	2	18.22	0/20*	—
	3	8.98	0/20*	—
	1	15.14	0/20*	—
	2	20.22	0/20*	—
	3	12.65	0/20*	—
Percussion's priming materials	1	0.74	212	62.4
	2	0.68	144	95.0
	3	0.56	194	49.9
	1	0.78	234	59.1
	2	0.75	185	92.5
	3	0.56	204	91.6
	1	1.56	248	46.4
	2	0.71	189	109.5
	3	0.56	194	76.1
	1	1.51	210	53.4
	2	0.89	164	74.2
	3	0.69	215	32.9
	1	2.52	232	104.3
	2	4.13	839	82.7
	3	2.79	168	53.2
	1	4.19	839	184.4
	2	6.39	0/25*	—
	3	4.28	216	83.9

* Explosion's probability, sample size=20 or 25 at maximum load=35.6kg

DDNP is linearly desensitised as its water content increases. And so the relations between water content (W) & 50% explosion load (P) are given as follows:

$P=13.06+0.70W$ for granular crystal, $\Delta=0.557$

$P=10.05+0.87W$ for granular crystal, $\Delta=0.427$

$P=9.51+0.56W$ for granular crystal, $\Delta=0.316$

Among the three kinds, the needle crystal is the most sensitive compared with other granulars and the grnular crystals seem to be slightly more sensitive at a lower bulk density ($\Delta=0.427$) than at a higher density ($\varDelta=0.577$).

Mercury fulminate is very sensitive in a dry state, generaitive than DDNP and it is scarecely desensitised even when it contains from 6% to 20% of water.

Percussion's priming materials are abruptly desensitised by havig a small percentage of water added and become remarkably insensitive when above 8% of water is added.

The main constituent, lead styphnate is most sensitive in a dry state but is linearly desensitised by water. And so the relation between water content (W) and 50% explosion load (P) is given as follows:

$P=1.28+1.27W$

In view of the above impact and friction sensitivity test the reasonable conclusion to be drawn from available data is as follows.

DDNP is more sensitive in needle crystal than in granular crystal, and it is linearly desensitised by water. DDNP is more insensitive than mercury fulminate.

Mercury fulminate is very sensitive in a dry state and is not linearly desensitised by water; it is not made so insensitive even when 20% of water is added, though it used to be stored in water.

Percussion's priming materials and their main constituent lead styphnate are abruptly desensitised by water. In friction sensitivity, so-called practical handling sensitivity, lead styphnate is most sensitive in a dry state but fortunately it is linearly desensitised by water.

4. Hess Initiation and Propagation Sensitivity

In the above impact and friction sensitivity tests only a small quantity of each sample is used. The growth of explosion accidents depends on the initiation and propagation of explosin. For this reason the author has measured the practically sufficient initiation and propagation sensitivity by modifying Hess Test[6] in which each sample (50g) is initiated by No. 6 detonator (equivalent to foreign. No. 8), which may give enough energy.

(1) Experimental Procedure

A sample is put into brown paper cylindér, 40 mm in dia., at its loading density and No. 6 electric detonator is inserted to the upper level height of initial explosives.

Two lead cylinders, 40 mm in dia. & 30 mm in height, are heaped up, measured with caliper and marked with a line at cylinder side through.

The steel plate, 40 mm in dia. & 4 mm in thickness, is put on the upper surface of the two heaped lead cylinders and the sample with a detonator inserted is put on the steel plate.

After initiation, depresson of the lead cylinders is measured with caliper, connecting a line mark at cylinder side.

Experiments are carried out at sample size 3 and water is added up to 90%.

(2) Experimental Results

The relations between water content and loading height, loading density, lead cylinder depression are shown in Table 4, Fig. 5

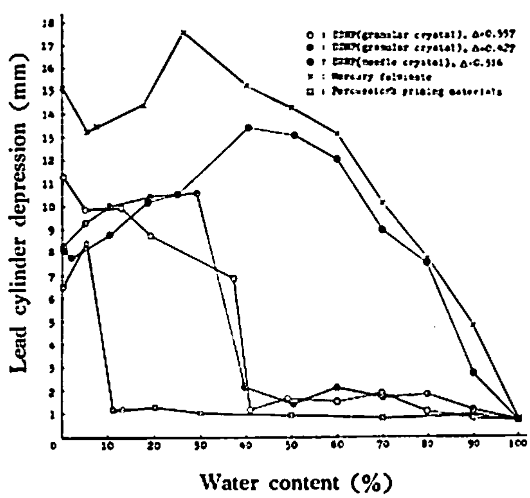

Fig. 5 The effect of water content on the lead cylinder depression of various initial explosives.

Table 4 The effect of water content on the lead cylinder depression of various initial explosives

Explosive	Water content (%)	Loading height (mm) Explosive level	Loading height (mm) Water level	Loading density (g/cm³) Observed value	Loading density (g/cm³) Mean value	Lead cylinder depression (mm) Observed value	Lead cylinder depression (mm) Mean value
DDNP (granular crystal) Δ=0.557	0.42	52.0		0.77	0.75	11.85	11.23
		52.4		0.76		10.60	
		54.5		0.73		11.30	
	4.72	53.5		0.74	0.75	11.55	9.93
		52.2		0.76		8.90	
		53.0		0.75		9.35	
	10.26	48.2		0.83	0.81	10.10	59.6
		48.0		0.83		9.00	
		51.0		0.78		10.85	

Explosive	Water content (%)	Loading height (mm)		Loading density (g/cm^3)		Lead cylinder depression (mm)	
		Explosive level	Water level	Observed value	Mean value	Observed value	Mean value
DDNP (granular crystal) Δ=0.557	19.06	47.2 47.5 47.8		0.84 0.84 0.83	0.84	9.30 8.95 8.35	8.87
	30.74	39.5 40.5 39.5		1.01 0.98 1.01	1.00	5.05 9.20 6.50	6.92
	40.88		33.5 34.5 35.5	1.19 1.15 1.12	1.15	1.30 1.00 0.95	1.08
	49.20		31.5 31.5 34.1	1.26 1.26 1.17	1.23	1.10 2.55 1.80	1.82
	60		35.2 33.7 33.9	1.13 1.18 1.17	1.16	2.1 0.7 1.7	1.50
	70		37.4 37.5 38.4	1.06 1.06 1.04	1.05	2.5 1.7 0.8	1.67
	80		38.2 38.6 38.4	1.04 1.03 1.04	1.04	2.2 0.5 0.4	1.03
	90		41.8 42.7 40.9	0.95 0.93 0.97	0.95	0.9 0.7 1.1	0.90
DDNP (granular crystal) Δ=0.427	0.36	65.0 65.0 66.2		0.61 0.61 0.60	0.61	7.75 8.30 8.95	8.27
	4.80	64.5 58.0 61.5		0.62 0.69 0.65	0.65	9.50 9.10 9.30	9.30
	9,86	57.5 57.7 57.9		0.69 0.69 0.69	0.69	9.40 9.50 11.10	10.00
	18.92	53.5 52.8 53.8		0.74 0.75 0.74	0.75	11.00 9.65 10.55	10.40
	29.38	47.0 47.0 46.7		0.85 0.85 0.85	0.85	12.30 9.45 9.90	10.55
	39.58		35.5 34.5 35.5	1.12 1.15 1.12	1.13	1.45 2.65 2.30	2.13

Explosive	Water content (%)	Loading height (mm)		Loading density (g/cm³)		Lead cylinder depression (mm)	
		Explosive level	Water level	Observed value	Mean value	Observed value	Mean value
DDNP (granular crystal) Δ=0.427	50.05		31.5 32.1 31.5	1.26 1.24 1.26	1.28	1.10 1.35 1.80	1.42
	60		37.2 36.3 36.8	1.07 1.10 1.10	1.09	1.80 2.80 1.70	2.10
	70		37.6 38.1 37.6	1.05 1.04 1.06	1.05	2.05 1.60 1.50	1.72
	80		38.5 39.8 40.8	1.04 1.00 0.97	1.00	1.50 1.70 2.30	1.83
	90		40.0 39.6 39.2	0.99 1.00 1.01	1.00	0.90 1.35 1.15	1.13
DDNP (needle crystal) Δ=0.316	0.09	88.5 87.6 87.8		0.46 0.45 0.46	0.46	7.50 8.85 8.20	8.18
	1.58	79.1 79.9 82.6		0.49 0.50 0.48	0.49	7.30 8.60 7.70	7.86
	10.41	72.6 74.8 77.2		0.55 0.53 0.52	0.53	8.50 8.60 9.50	8.86
	18.61	66.5 68.2 67.4		0.60 0.58 0.59	0.59	9.80 10.45 10.30	10.18
	25.08	53.7 53.4 58.8		0.74 0.74 0.68	0.72	11.80 10.00 9.75	10.52
	40.51		30.5 27.0 27.0	1.31 1.47 1.47	1.42	14.20 12.35 13.35	13.36
	50.72		31.2 31.5 31.5	1.28 1.26 1.26	1.27	13.70 13.05 12.35	13.03
	60	16.1 17.2 17.8	32.2 34.3 34.7	1.24 1.16 1.15	1.18	12.80 13.10 10.80	12.23
	70	16.4 15.3 17.8	34.4 36.2 35.3	1.16 1.10 1.13	1.13	10.40 6.70 9.80	8.97

Explosive	Water content (%)	Loading height (mm)		Loading density (g/cm³)		Lead cylinder depression (mm)	
		Explosive level	Water level	Observed value	Mean value	Observed value	Mean value
DDNP (needle crystal) Δ=0.316	80	7.9	34.5	1.15	1.10	7.10	7.50
		10.8	36.0	1.10		9.45	
		7.3	37.8	1.05		5.95	
	90	4.3	38.0	1.05	1.04	2.00	2.27
		4.7	38.9	1.02		3.00	
		4.9	38.4	1.04		1.80	
Mercury fulminate	0.02	24.5		1.62	1.59	16.25	15.15
		25.5		1.56		14.30	
		25.0		1.59		14.90	
	5.07	27.1		1.47	1.50	14.10	13.23
		26.2		1.52		12.60	
		26.4		1.51		13.00	
	7.09	23.5		1.69	1.68	13.60	13.42
		24.2		1.64		12.45	
		23.5		1.69		14.20	
	17.45	20.2		1.97	1.96	13.95	14.33
		21.1		1.89		13.95	
		19.8		2.01		15.10	
	26.28		17.2	2.32	2.34	18.45	17.52
			17.4	2.29		16.80	
			16.4	2.43		17.30	
	40	16.1	22.0	1.81	1.81	16.40	15.17
		15.7	21.5	1.85		14.60	
		16.2	22.4	1.78		14.50	
	50	13.2	25.5	1.56	1.57	13.75	14.22
		13.0	24.9	1.60		13.90	
		12.7	25.5	1.56		15.00	
	60	12.5	25.5	1.56	1.41	14.55	13.03
		12.2	30.0	1.33		12.65	
		10.5	29.8	1.33		11.90	
	70	10.2	29.2	1.36	1.33	10.70	10.12
		10.9	30.2	1.32		9.20	
		9.7	30.7	1.30		10.45	
	80	4.5	31.5	1.26	1.22	7.70	7.70
		4.8	32.0	1.24		8.40	
		6.0	34.2	1.16		7.00	
	90	2.4	39.0	1.02	1.04	4.20	4.83
		2.4	38.5	1.03		5.00	
		3.2	37.5	1.06		5.30	
Percussion's priming materials	0.79	34.5		1.15	1.17	6.00	6.48
		34.2		1.16		6.40	
		33.5		1.19		7.05	

Explosive	Water content (%)	Loading height (mm)		Loading density (g/cm³)		Lead cylinder depression (mm)	
		Explosive level	Water level	Observed value	Mean value	Obsedved value	Mean value
Percussion's priming materials	5.05	26.5 26.4 27.0		1.50 1.51 1.47	1.50	8.65 8.35 8.20	8.40
	10.67	15.5 16.5 16.3		2.57 2.41 2.44	2.48	1.00 1.10 1.30	1.13
	12.80		15.5 16.2 16.8	2.57 2.46 2.37	2.46	1.10 1.15 1.35	1.20
	20		21.55 21.80 21.90	1.85 1.82 1.83	1.83	1.40 1.20 1.20	1.27
	20		25.10 24.70 24.20	1.59 1.61 1.64	1.61	1.00 0.90 1.20	1.03
	50		29.90 29.60 28.60	1.33 1.35 1.38	1.35	1.00 1.00 0.90	0.97
	70		31.40 31.00 34.00	1.27 1.28 1.17	1.24	1.10 0.90 0.50	0.83
	90		36.20 36.40 36.10	1.10 1.09 1.10	1.10	1.00 1.00 0.90	0.97

Granular DDNP both fail when they contain above 40% of water, but needle DDNP gives the maximum lead cylinder depression when it contains 40~50% of water and is not abruptly desensitised even when it contains 90% of water. All DDNP lixivates water on its surface when it contains above 39.5% of water.

Mercury fulminate has the same tendency as needle DDNP. Maximum depression is observed when it contains about 30% of water and even when it contains 90% of water it has considerable depression. It lixivates water on its surface when it contains above 26.8% of water.

Percussion's priming materials fail when they contain above 10% of water and lixivate water on its surface when it contains above 12.8% of water. Therefore 10% is the standard of water content for maintaining safety in handling processes.

Lead cylinder depression when 50g of water with no initial explosive is initiated by No. 6 electric detonator is 0.7 mm. And so when the depression is over 0.7 mm explosives are more or less initiated and propagated.

(3) Discussion

It is observed that needle DDNP mercury and fulminate have distinctly maximum depressions.

Since the total charge is constantly 50g, the depression is ought to decrease gradually, as water content increases.

Experimental relations between dry explosive charge and lead cylinder depression are given in Fig. 6.

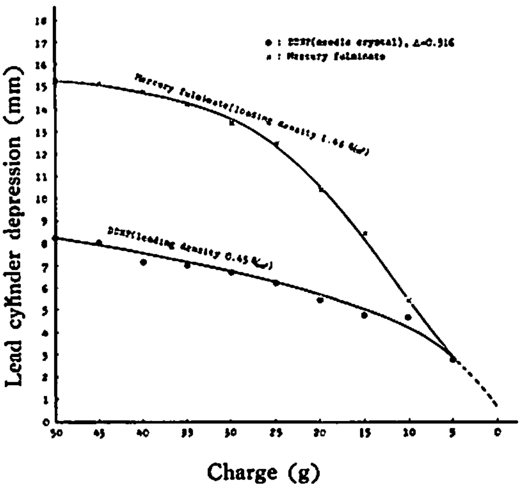

Fig. 6 The effect of initial explosive's charge on the lead cylinder depression.

From the data of Table 4, the relations water content and loading density are shown in Fig. 7.

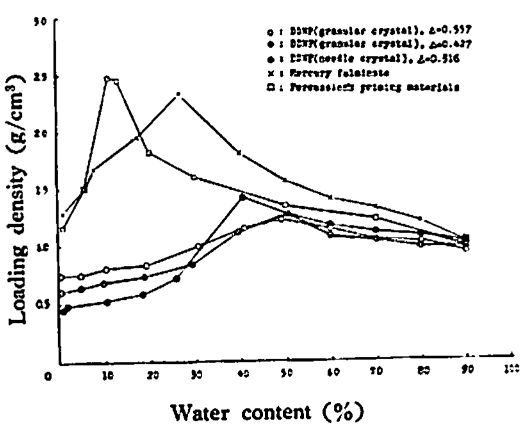

Fig. 7 The effect of water content on the loading density of various initial explosives

This patterrn is similar to the maximum tendency distinctly observed in needle DDNP and mercury fulminate.

It can be concluded that the maximum tendency depends mainly upon the relations between water content and the variation of loading density.

5. Conclusions

The preceding observations suggest the quantitative standards of maintaining safety in handling initial explosives concerning their manufacture, storage and transport.

(1) Impact, friction and Hess initiation sensitivity tests were modified and conducted by adding water to a dry state of DDNP (granular high bulk density, granular low density and needle crystal), mercury fulminate, lead styphnate and percussion's priming materials.

(2) The sensitivity difference between granular crystal at high bulk density and granular crystal at low bulk density is not so clear, but granulars were less sensitive than needle crystal.

When granulars contain above 40% of water they are desensitised and practically cease to be dangerous, but needle crystal is not so desensitised.

(3) DDNP is very insensitive compared with mercury fulminate which was previously used as commercial initial explosives.

(4) Mercury fulminate is very sensitive in a dry state and is not gradually desensitised even by existence of water

Neither mercury fulminate nor needle DDNP is sufficiently desensitised oney by water. To secure safety, other means should be searched.

(5) Lead styphnate and percussion's priming materials are abruptly desensitised when a small percentage of water is added. Lead styphnate has the most sensitive friction sensitivity in a dry state.

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起爆薬の感度に関する実験

沢　田　維　男

起爆薬の製造，貯蔵，運搬に関する取扱い上の保安基準資料を得るため，工業的に賞用される鈍化剤として水を添加し，衝撃，摩擦，起爆感度試験を行なった。

衝撃感度試験には，M. P. Murgai & A. K. Ray が雷汞の衝撃感度の研究に用いた落鋼球式のものを，若干改良して使用した。

DDNP は粒状結晶のものの，仮比重による感度の差異は明かではないが，針状結晶のものは，粒状に比し鋭敏である。

DDNP は，従来工業用起爆薬として用いられた雷こうに比較すると，著しく鈍感である。

DDNP は，水分添加により，直線的に鈍化されるが，雷こうは鈍化され難く可成りの鋭敏さを維持する。

銃用爆粉点爆剤及びその主成分であるスチフニン酸鉛は，数%の水分添加により，急激に鈍化され雷管によつても起爆されなくなる。併しスチフニン酸鉛は，乾燥状態では摩擦感度極めて鋭敏であり，取扱上注意すべきである。

ニュース

弱い爆発力を利用した米社の新爆発成形法

アセチレン化銀，硝酸銀の爆発力を利用した爆発成形法が，アメリカのサウスウエスト・リサーチ，インスティチュートで開発された。10吋^{2}当り，TNT は 100 psi ミリ秒以上の爆圧力を出すのに，この化合物は最高 50 psi ミリ秒しか出さない。この新爆発成形法はこの化合物をアセトンと混合してスラリーを作り，それを加工体表面に吹きつけて，乾かして被覆にし，そこへ強いインパルスをあてて全面同時に爆発させる方法である。この方法は小さくて複雑な形をしたものの成形に使われる。点火するのは熱や電気火花より光のパルスの方がよい。この研究所ではこれを 0.1g 吹きつけて使っているが，TNT を使う場合は厚さが最低 1/4 インチで約 60g 以上を必要とし，しかも特別の装置を用い，水中で行なわねばならない。この化合物の爆発時間は普通 10 μsec 位である。普通の爆発成形と較べてどちらが安くつくかは簡単にいえないが，TNT がポンド約1ドルであるのに，この化合物は 1g づつ作つた所から見積るとポンド約25ドルするという。

（日刊工業　41.3.14, Chemrial & Engineering News 12.6 ; ('65))

熱電対による表面温度の新測定法

阪大（工）小笠原研究室で開発された。これは固体内部を通して別々に表面に到達させた熱電対素線の温接点を，メッキ処理で導通させ，一回路として表面温度を測定しよう，というものである。同研究室で試作したものは温度場の乱れを防ぐため 10.2 mm の銅及びコンスタンタン線を用いている。銅板の表面温度測定の例をあげると――。素線をそう入する小さい孔を銅板にあけて，これにコンスタンタン線を通す。この素線は完全に被覆絶縁をしたものであるが，これをエポキシ樹脂を充てんして固定する。樹脂が硬化したら測定面に貫通している素線を切りおとし，表面を平滑に仕上げる。表面を無電解銅メッキ処理をして，コンスタンタン線と銅板を電気的に導通させる。銅板と，引出し線に用いる銅線の組成が同じであれば，銅板の任意のところに銅線をとりつける事に依つて熱電対回路ができるわけである。（日刊工業　41. 3.18）