Laboratory

University of Tartu Testing Centre, work environment laboratory, EVS-EN ISO/IEC 17025:2006 accredited, accreditation certificate no L151 (issuer: Estonian Accreditation Centre)

Measurement devices

Device, make and model		Measurement range	Traceability
Noise analyser Brüel & Kjaer (S313)	Type 2260	31,5:16k Hz, 44,4…95 dB	OÜ Tehnokontrollikeskus, nr. KL-15-1-029 → Calibrator B&K 4226, national etalon of Denmark
Noise logger Casella (S309)	CEL-350/K5	70…140 dB(A)	Inspecta Estonia OÜ, nr. KL-165-2-131 → Calibrator B&K 4226, national etalon of Denmark
Vibration measurement set Brüel & Kjaer (S308)	WB 3461	0,306…5 m/s^2, WBV: 0,4…100 Hz HAV: 31,5-1000 Hz	Inspecta Estonia OÜ, nr. KL-165-3-016 → Etalon vibration transducer B&K8305, national etalon of Denmark

150 mm howitzer, shelling

Table 1: equivalent noise level and peak sound pressure level measurement results

No.	Measurement site	Measurement device no.	Time		Measurement results				Legal limits (re. EE law)	
			Start [hh:mm:ss]	Finish [hh:mm:ss]	Equivalent noise level [dB(A)]		Peak sound pressure [dB(C)]		Equivalent noise level [dB(A)]	Peak sound pressure [dB(C)]
					$L_{pAeq,t}$	$\pm U(L_{pAeq,t})$	$L_{pC,peak,t}$	$\pm U(L_{pC,peak,t})$	$L_{pAeq,t}$	$L_{pC,peak,t}$
1	Front left stack, top cot	CEL460-2	10:00:00	14:00:00	48,3	1,2	109,0	1,3	85	137
2	Middle right stack, bottom cot	CEL460-3	10:00:00	14:00:00	49,2	1,2	107,4	1,3		
3	Middle right stack, top cot	CEL460-6	10:00:00	14:00:00	50,2	1,2	105,3	1,3		
4	Back end right stack, top cot	CEL460-1	10:00:00	14:00:00	48,0	1,2	109,0	1,3		
5	Back end left stack, top cot	CEL460-4	10:00:00	14:00:00	50,5	1,2	105,4	1,3		

Table 2: whole-body vibration measurement results (summary)

No.	Measurement site	Time		Duration	Measurement axis	Maximum vibration level, "S" time weighted		Legal limit. 8 h average (re. EE law)
		Start [hh:mm:ss]	Finish [hh:mm:ss]			$a_{w,max}$ [m/s^2]	U($a_{w,max}$) [m/s^2]	$a_{w,max}$ [m/s^2]
1	Shelter floor, centre of axes	9:20:38	13:15:08	3:54:30	X[1]	0,21	0,01	1,25
					Y[2]	0,20	0,01	1,25
					Z[3]	0,19	0,01	1,25

[1] Transverse horizontal relative to shelter axis
[2] Parallel to shelter axis
[3] Transverse vertical relative to shelter axis

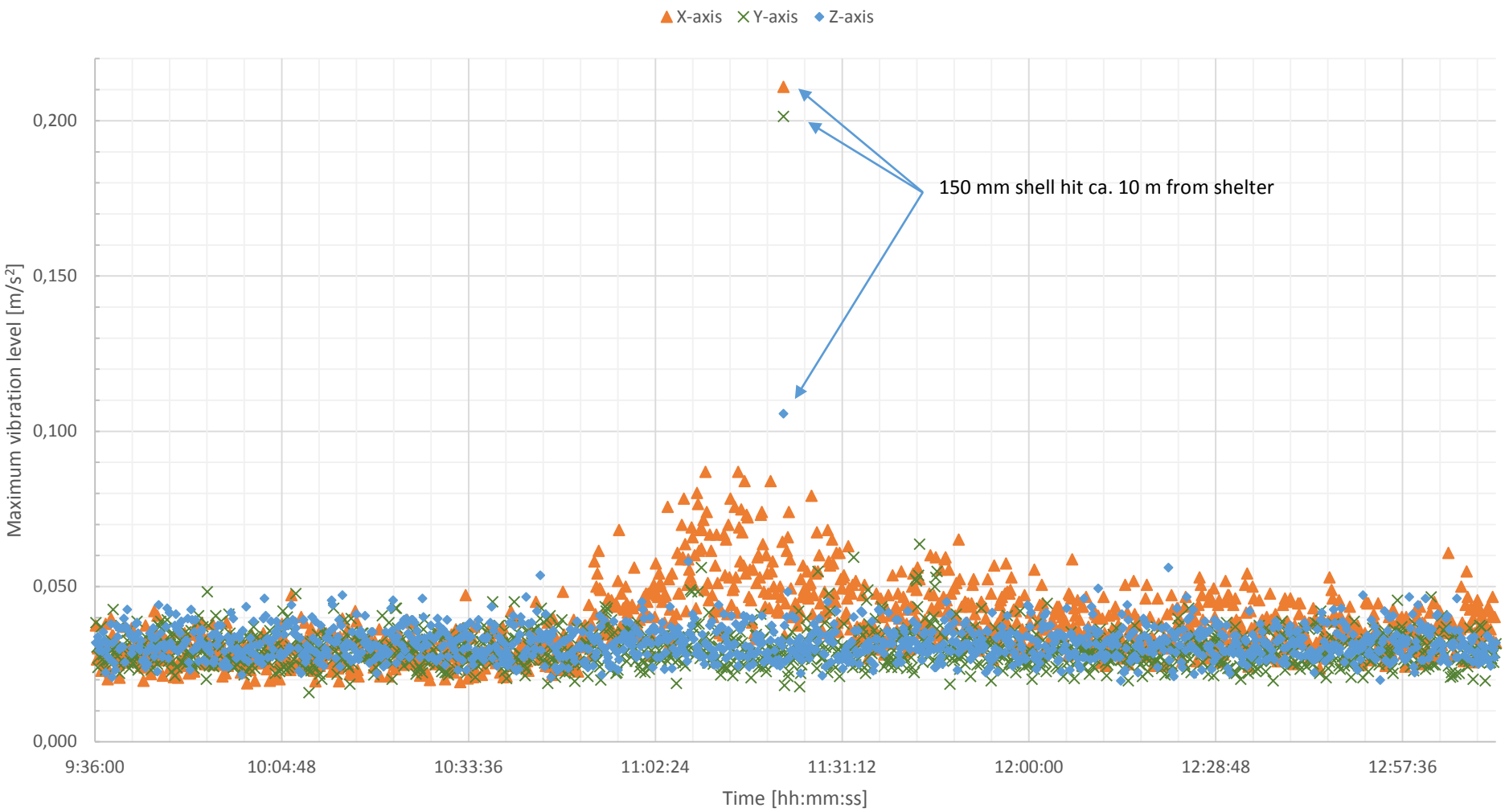

Figure 1: whole-body vibration, measurement results, timeline

81 mm mortar, shelling

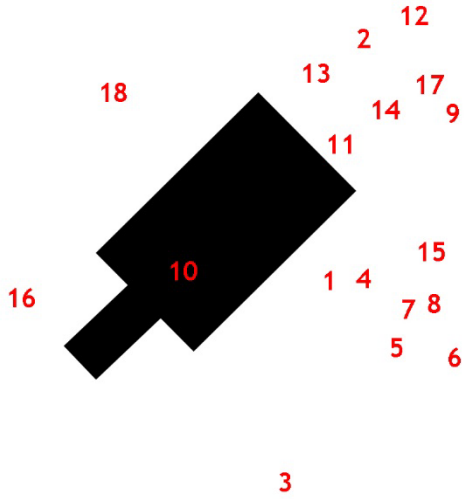

Figure 2: 81 mm mortar shelling hit map

Table 3: equivalent noise level and peak sound pressure level measurement results

No.	Measurement site	Measurement device no.	Measurement range [dB(C)]	Time		Measurement results				Legal limits (re. EE law)	
				Start [hh:mm:ss]	Equivalent noise level [dB(A)] $L_{pAeq,t}$	Peak sound pressure [dB(C)]		Equivalent noise level [dB(A)]		Peak sound pressure [dB(C)]	Equivalent noise level [dB(A)]
						$\pm U(L_{pAeq,t})$	$L_{pAeq,t}$	$\pm U(L_{pAeq,t})$	$L_{pAeq,t}$	$\pm U(L_{pAeq,t})$	$L_{pAeq,t}$
1	Front right stack	CEL460-6	50-125	7:09:00	9:41:50	67,7	1,6	>125	-		
2	Front left stack	CEL460-3	70-145	7:08:00	9:41:50	67,3	1,3	142,4	1,3		
3	Middle left stack	CEL460-1	70-145	7:10:00	9:41:50	67,5	1,3	139,9	1,3	85	137
4	Back end right stack	CEL460-2	70-145	7:08:00	9:40:50	69,1	1,4	140,3	1,3		
5	Back end left stack	CEL460-4	50-125	7:07:00	9:40:50	66,0	1,6	>125	-		

Table 4: peak sound pressure level measurement results, each event

No.	Time [hh:mm:ss]	Measurement device no. / Peak sound pressure [dB(C)], U=1,3 dB(C)					Legal limit (re. EE law) [dB(C)]
		CEL460-1	CEL460-2	CEL460-3	CEL460-4[4]	CEL460-6[4]	
1	8:56:00	132,2	132,0	135,6	>125	>125	
2	8:58:20	119,8	119,8	123,4	119,6	118,9	
3	9:01:00	125,3	128,2	129,4	126,4	>125	
4	9:03:40	131,3	131,1	132,8	>125	>125	
5	9:04:50	130,7	130,6	132,5	>125	>125	
6	9:07:10	115,8	116,3	133,2	>125	>125	
7	9:08:00	138,5	139,5	141,6	>125	>125	
8	9:12:10	133,0	133,9	135,4	>125	>125	
9	9:13:20	130,9	130,3	133,7	>125	>125	
10	9:15:20	131,8	131,6	133,7	>125	>125	137
11	9:16:10	116,8	117,6	130,5	>125	>125	
12	9:18:20	137,1	139,8	139,8	>125	>125	
13	9:19:20	139,9	140,3	142,4	>125	>125	
14	9:21:50	123,4	123,2	127,5	122,7	122,1	
15	9:22:50	134,6	135,0	138,2	>125	>125	
16	9:26:00	128,0	126,9	130,1	>125	>125	
17	9:26:50	131,8	131,4	133,8	>125	>125	
18	9:28:00	124,6	124,2	126,9	123,6	123,0	
Average $L_{pC,peak,t}$:		**129,2**	**129,5**	**133,4**	**125,9**	**124,7**	

[4] Device with lower measurement range: 50-125 dB

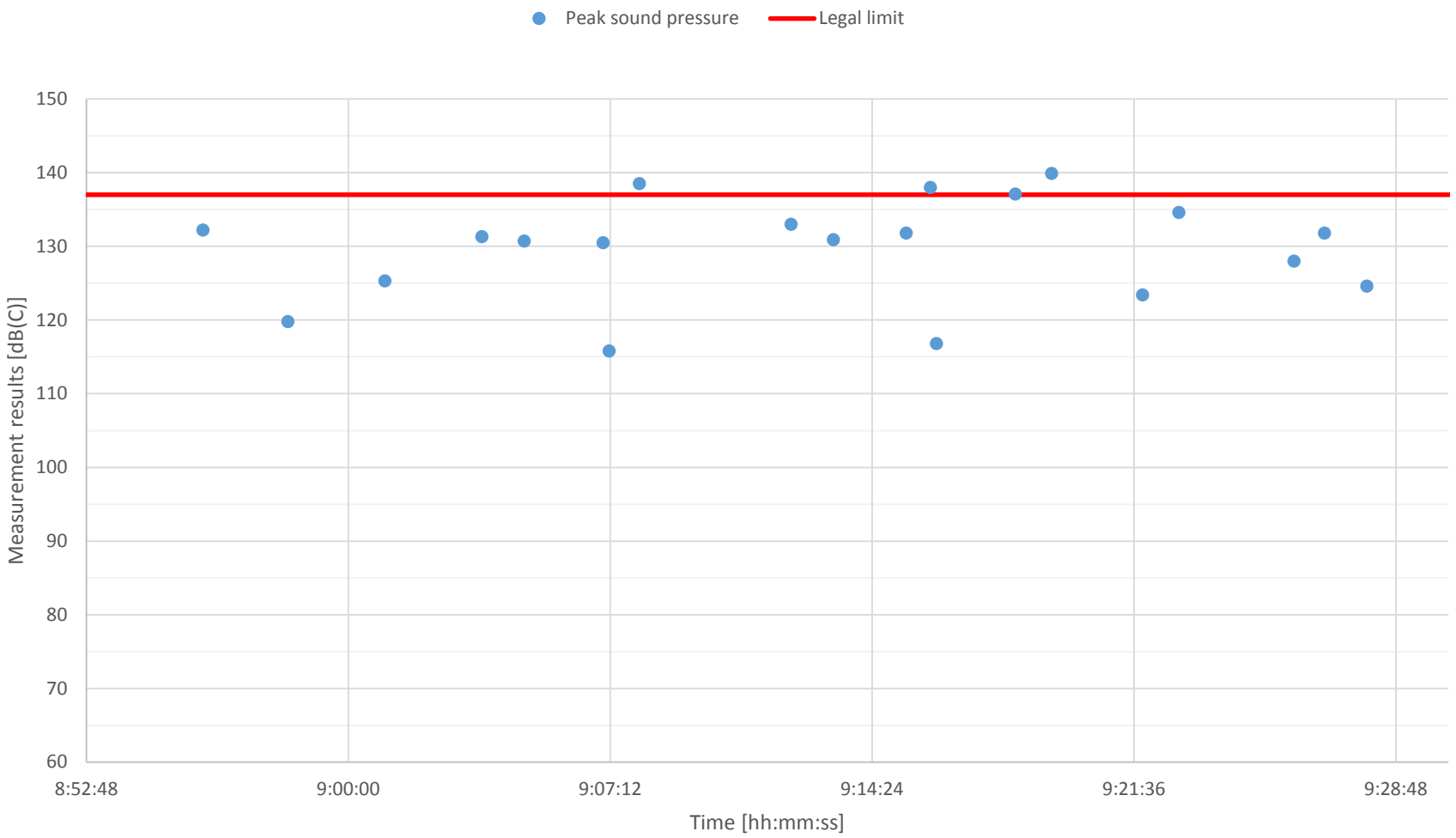

Figure 3: peak sound pressure level measurement results, each event, CEL460-1

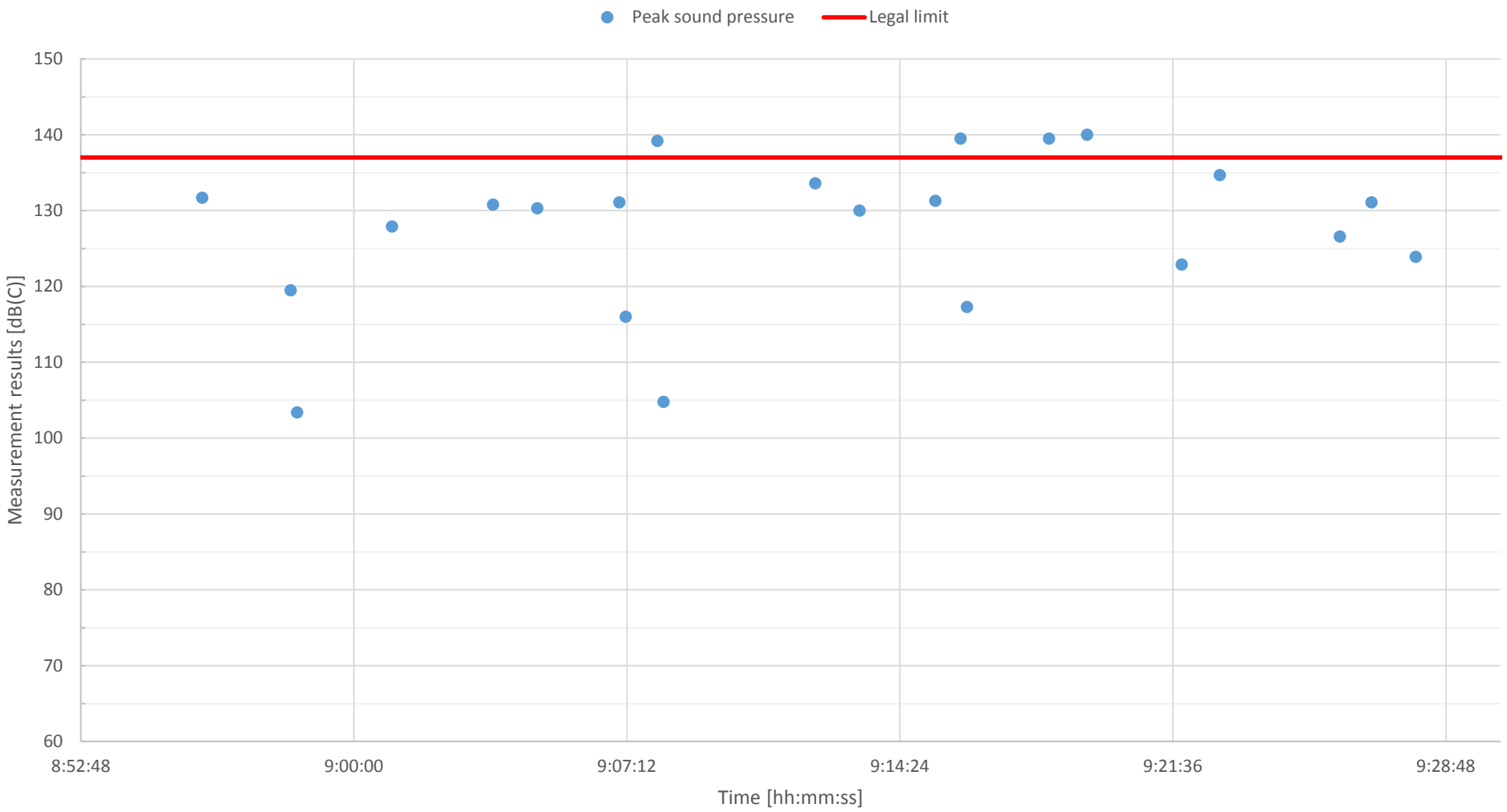

Figure 4: peak sound pressure level measurement results, each event, CEL460-2

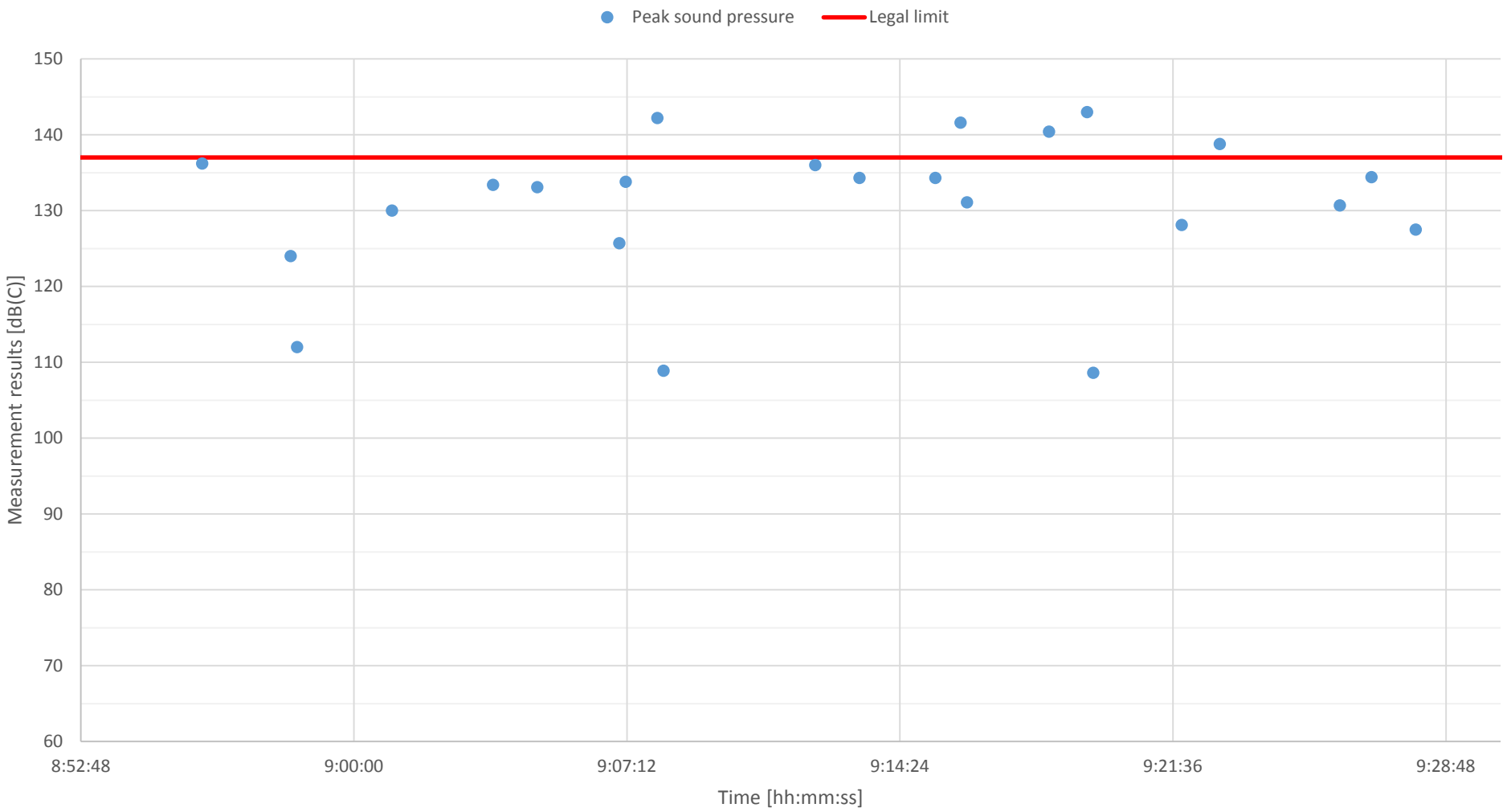

Figure 5: peak sound pressure level measurement results, each event, CEL460-3

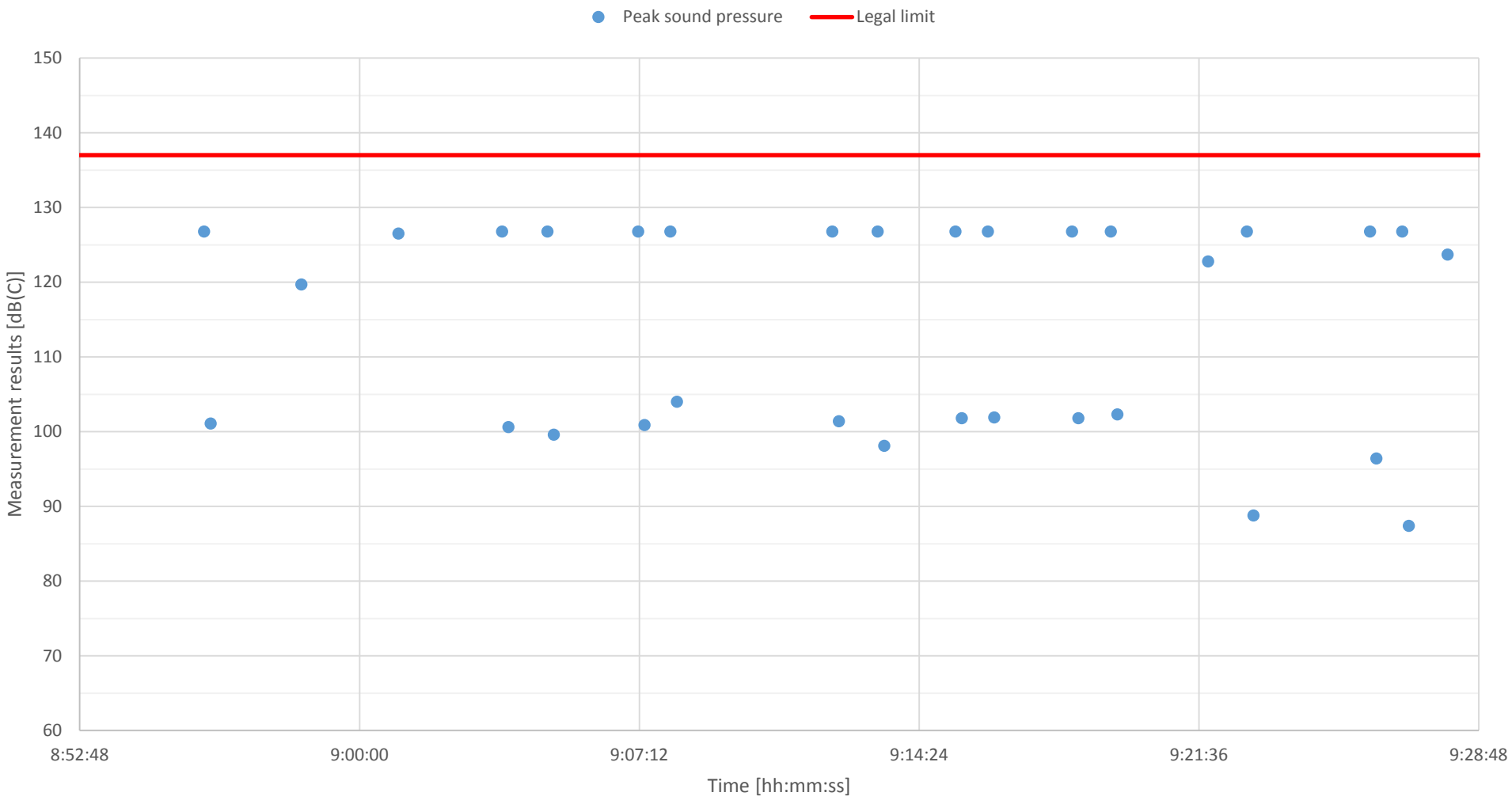

Figure 6: peak sound pressure level measurement results, each event, CEL460-5 (results over 125 dB(C) indicate measurement device overload)

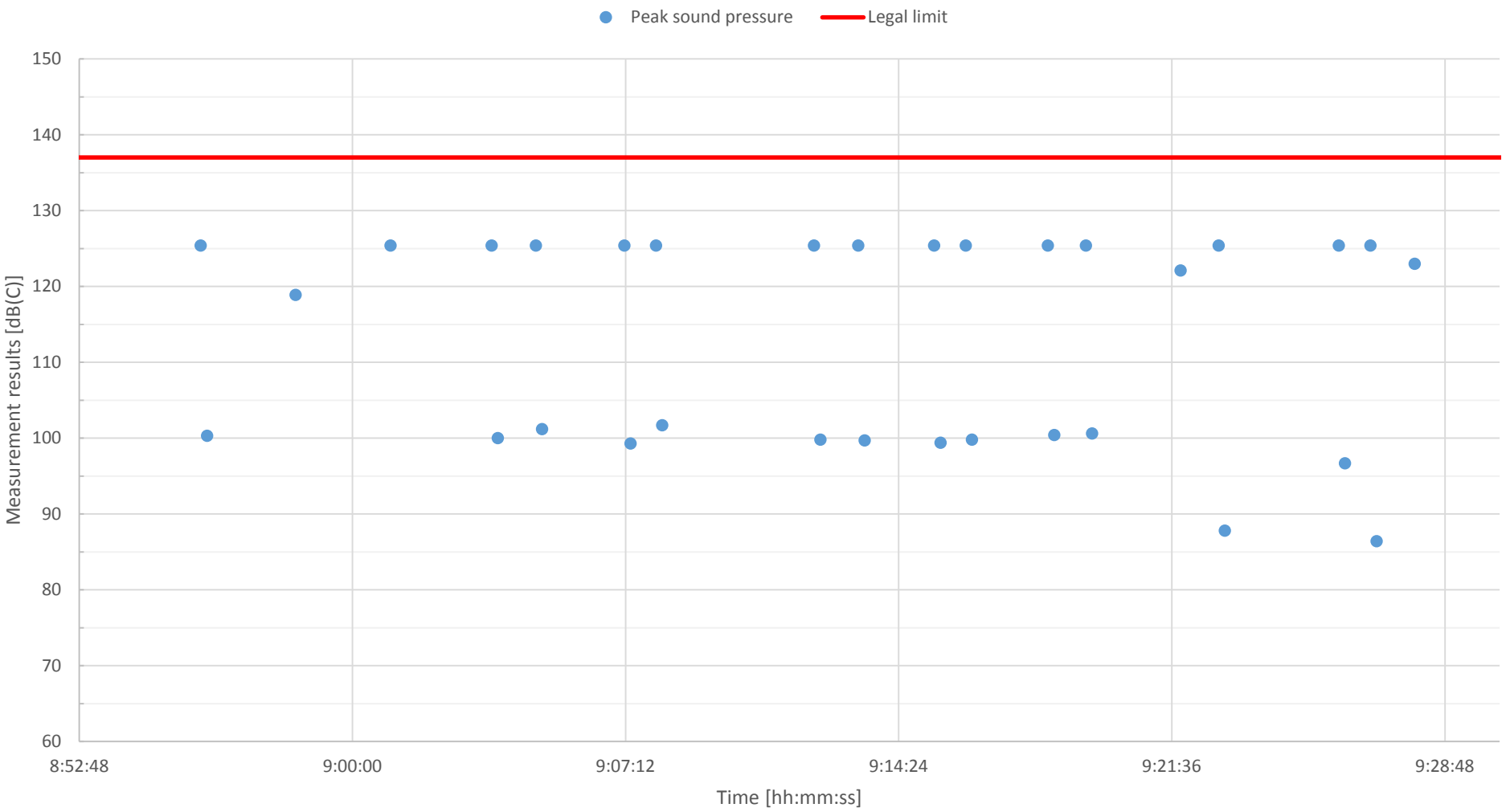

Figure 7: peak sound pressure level measurement results, each event, CEL460-6 (results over 125 dB(C) indicate measurement device overload)

Ordinance detonation test

Table 5: peak sound pressure level measurement results, each event

No.	Event description	Time [hh:mm:ss]	Measurement device no. and site / Measurement results								Legal limit
			CEL460-1 Centre left stack		CEL460-2 Rear right stack		CEL460-3 Front left stack		CEL460-4 Rear left stack		
			$L_{pC,peak,t}$ [dB(C)], ±1,3 dB(C)	$L_{pAeq,t}$ [dB(A)] ±1,3 dB(A)	$L_{pC,peak,t}$ [dB(C)], ±1,3 dB(C)	$L_{pAeq,t}$ [dB(A)] ±1,3 dB(A)	$L_{pC,peak,t}$ [dB(C)], ±1,3 dB(C)	$L_{pAeq,t}$ [dB(A)] ±1,3 dB(A)	$L_{pC,peak,t}$ [dB(C)], ±1,3 dB(C)	$L_{pAeq,t}$ [dB(A)] ±1,3 dB(A)	$L_{pC,peak,t}$ [dB(C)]
1	44-50 kg explosive charge next to entrance	10:44:10	>145	107,1	>145	105,8	>145	105,7	>145	106,6	137
2	120 mm mortar shell on top of shelter	10:58:20	117,1	84,2	115,7	84,6	116,2	84,4	114,3	84,2	
3	120 mm mortar shell to the left of shelter	11:21:40	>145	113,6	>145	112,6	>145	111,8	>145	111,6	
4	122 mm howitzer shell on top of shelter	11:36:20	>145	115,8	>145	114,6	>145	115,2	>145	114,9	
5	122 mm howitzer shell to the left of shelter	11:45:50	>145	111,8	>145	109,9	>145	109,3	>145	110,5	
6	122 mm howitzer shell dug 1 m into ground to the right of shelter	12:06:30	>145	112,4	>145	110,7	>145	110,5	>145	111,2	
7	10 kg explosive charge on top of shelter	12:26:40	>145	123,4	>145	122,2	>145	122,2	>145	121,8	

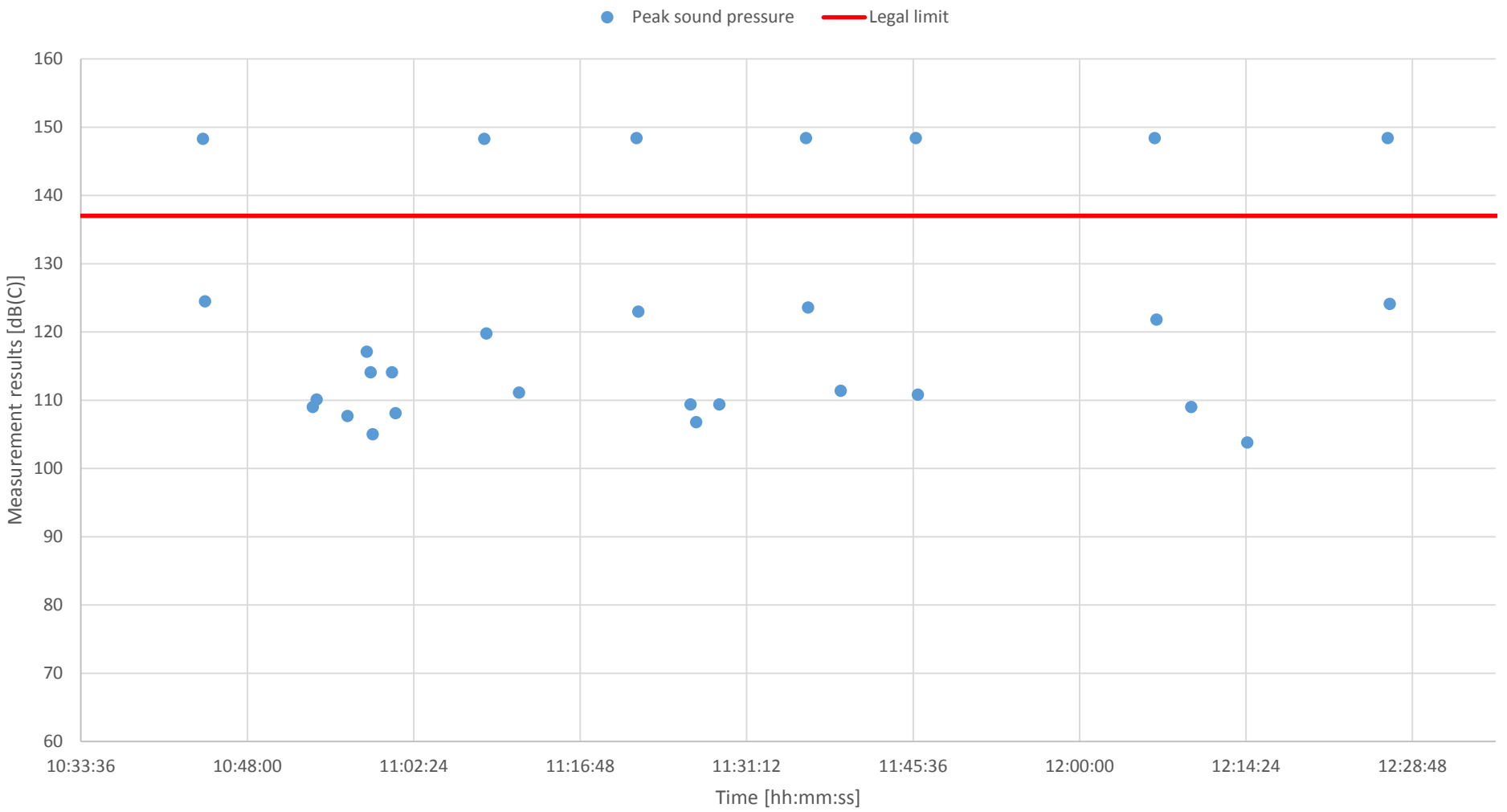

Figure 8: peak sound pressure level measurement results, each event, CEL460-1

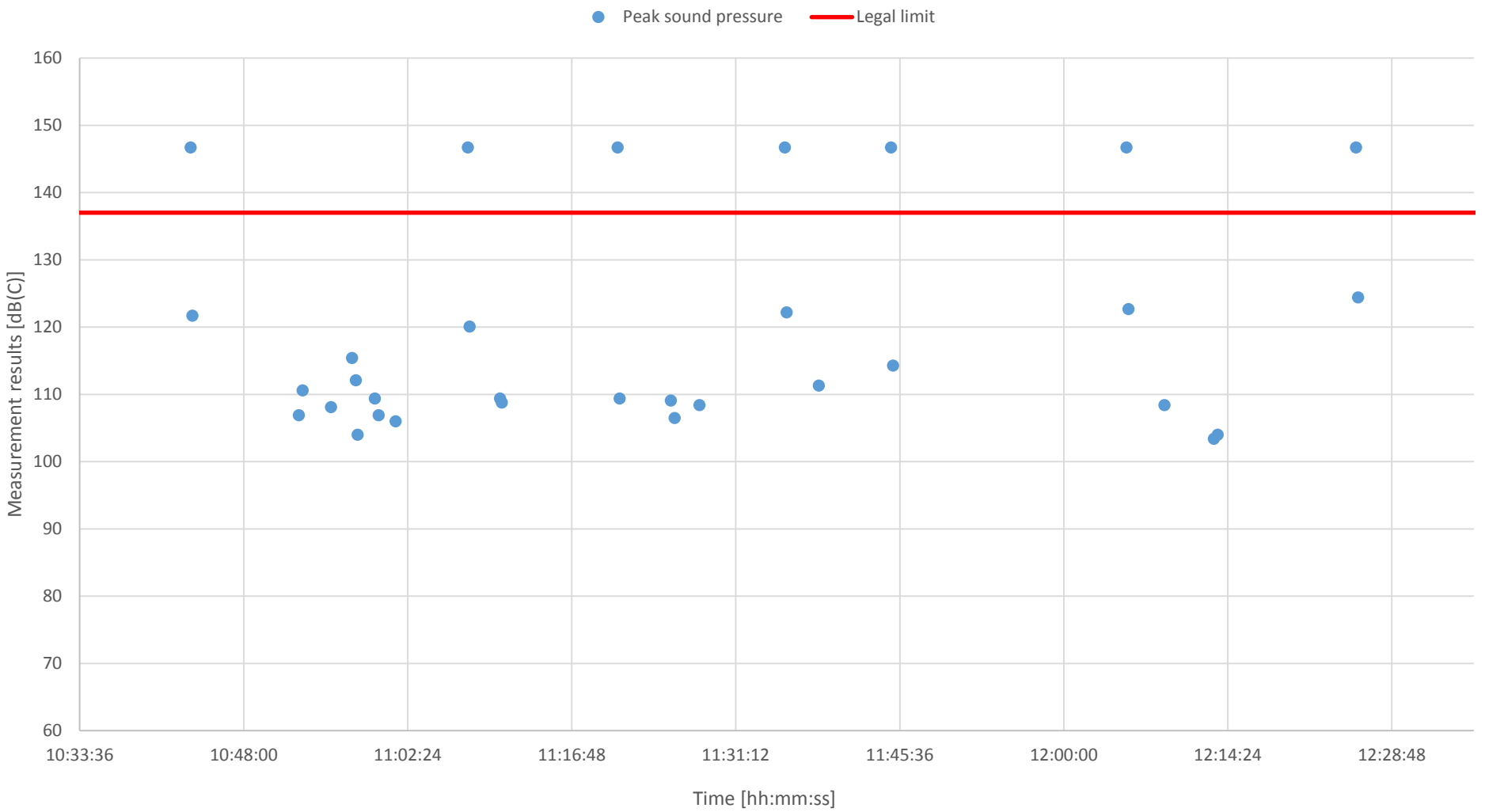

Figure 9: peak sound pressure level measurement results, each event, CEL460-2

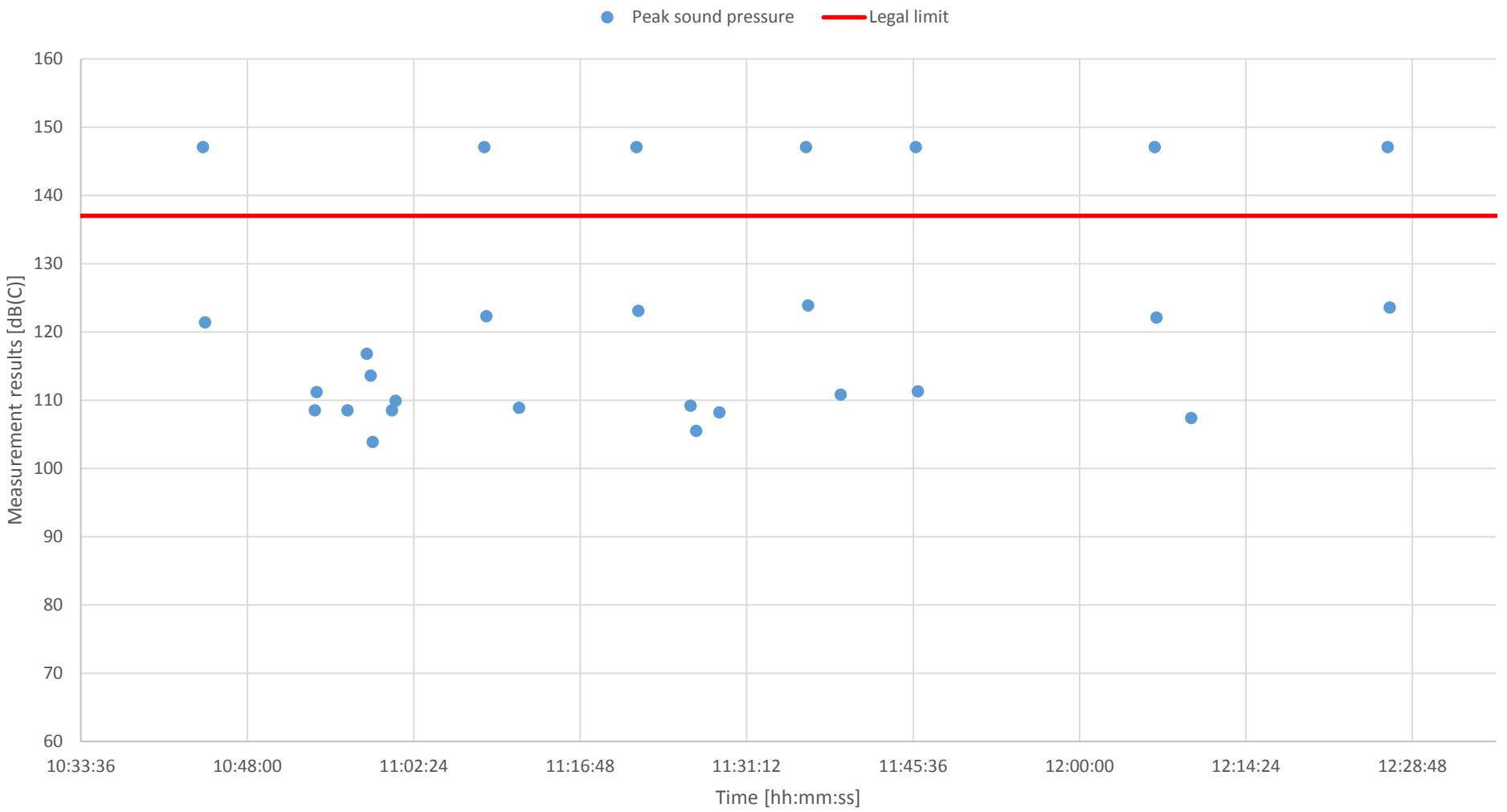

Figure 10: peak sound pressure level measurement results, each event, CEL460-3

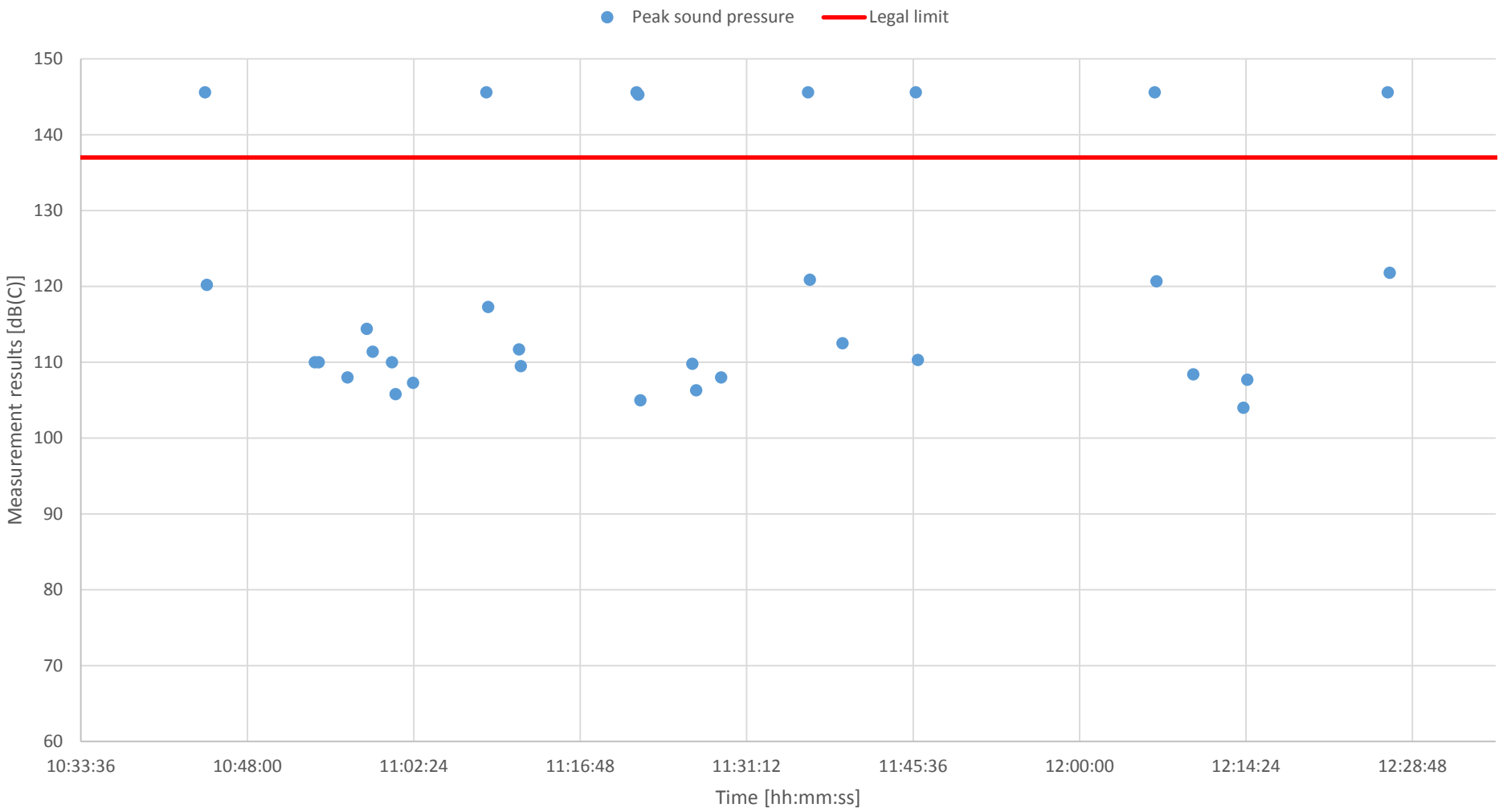

Figure 11: peak sound pressure level measurement results, each event, CEL460-4