MEASUREMENTS

Output Power

The power radiated by each EMS therapy unit was measured against the NPL Reference Balance. Each was configured according to the output settings specified in the RESULTS section of this certificate. This report is only valid for these output settings.

The transducer was mounted in the top of the balance so that it radiated vertically downwards. The acoustic power radiated in the forward direction was measured using the NPL Reference Balance, with the tank filled with degassed, deionised water. The balance was fitted with an absorbing target manufactured from NPL absorber. The separation between the transducer face and the target was between 5 and 10 mm approximately. The experimental arrangement (with an NPL reference transducer under test) is shown in Figure 1.

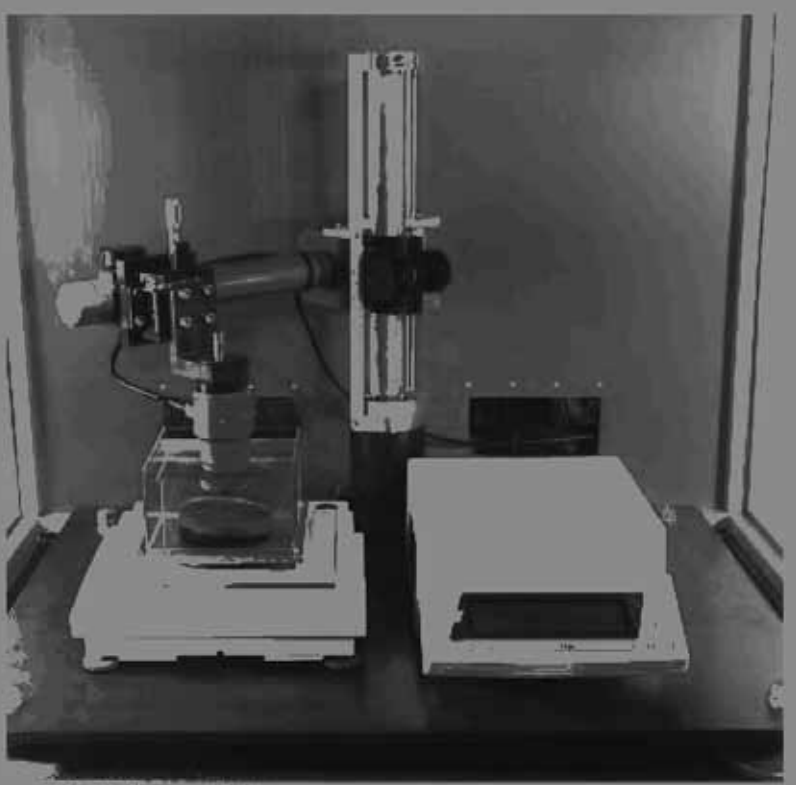

Figure 1: NPL Reference Balance

The EMS unit and transducer were switched on for at least 1 hour (with the output of the unit switched off) prior to measurement in order for the drive unit and treatment head to reach thermal equilibrium. Measurements were made by recording the mean change in the NPL Balance reading produced by switching the EMS unit ON and OFF. The balance was interfaced to a PC and the change in weight of the target recorded as a function of time for the duration of each measurement set. The resulting data set was analysed using an extrapolation technique to determine the change in the radiation force at each ON-OFF and OFF-ON transition. An equivalent acoustic power for each transition was calculated and the mean value was taken to be the measured power from the transducer. A measurement set consisted of at least four ON-OFF transitions. Two independent sets of measurements were made at each excitation setting with the transducer being removed from the NPL Balance between each measurement set. There was no significant difference observed between the ON-OFF and OFF-ON readings.

Measurements were made with the physiotherapy system operating at a nominal output setting of 0.5 W cm^{-2}, in continuous wave (CW) mode, and in 1:4 pulsed wave (PW) mode.

Note: The transducer was energised at the start of each ON period by rotating the output control so that the appropriate nominal power level as stated in the RESULTS section was indicated on the display. At the end of the ON period the output control was rotated back to zero.

Effective radiating area determination

To determine the effective radiating area (A_{ER}), the acoustic power radiated in the forward direction was measured using the NPL Therapy-Level Balance, with the tank filled with degassed, deionised water. The balance was fitted with a reflecting target of 60 mm diameter. The balance was used in conjunction with the NPL Apertures (see Figure 2), which selectively attenuate concentric regions of the radiated field, thereby allowing the determination of the output power as a function of aperture diameter. The separation between the transducer face and the aperture, and between the output surface of the aperture and the target, was approximately 2 mm in each case. The EMS unit was switched on for at least 1 hour (with the output of the unit switched off) prior to measurement in order for the drive unit and treatment head to reach thermal equilibrium.

Figure 2: NPL Apertures for effective radiating area determination

For each aperture size chosen, the transducer was mounted in the top of the balance, above the aperture, so that it radiated vertically downwards. A schematic diagram of the experimental set up is shown in Figure 3.

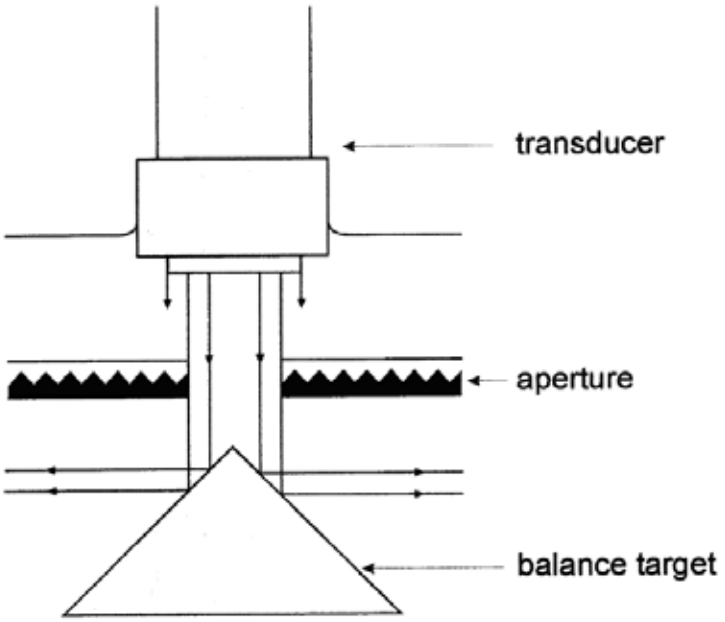

Figure 3: Schematic diagram of aperture arrangement

Measurements of output power for each aperture size were then made by recording the mean change in the balance reading (in units of watts) produced by switching the unit ON and OFF. A measurement set consisted of two OFF-ON-OFF transitions. There was no significant difference observed between the ON-OFF and OFF-ON readings. Measurements were made using the physiotherapy system under test in CW mode only. For each physiotherapy system, a minimum of 12 aperture diameters was used to determine a value for A_{ER}, using an analysis technique analogous to that described in standard IEC 61689.

RESULTS

System details	Output settings	Nominal Power	Output Power	Effective radiating area
90566/91471	CW, 0.5 W cm^{-2}	2.0 W	2.2 W ± 5 %	4.1 cm^2 ± 10 %
	PW 1:4, 0.5 W cm^{-2}	0.4 W	0.46 W ± 5 %	
90255/88874	CW, 0.5 W cm^{-2}	2.0 W	2.2 W ± 5 %	4.2 cm^2 ± 10 %
	PW 1:4, 0.5 W cm^{-2}	0.4 W	0.44 W ± 5 %	

The mean temperature of the water within the balance tank during measurements was 22.0 ± 0.5 °C.

The reported uncertainty in output power is based on a standard uncertainty multiplied by a coverage factor, k=2, providing a level of confidence of approximately 95%. The reported uncertainty in the effective radiating area is an estimate of the overall uncertainty, based on reference measurements made using a similar experimental arrangement.

EMS Unit/ transducer	CW output power (W)	Deviation from nominal (%)	PW output power (W)	Deviation from nominal (%)	Effective radiating area (cm^2)	Deviation from nominal (%)	CW Effective intensity (W/cm^2)	Deviation from nominal (%)	PW Effective intensity (W/cm^2)	Deviation from nominal (%)
91902/91582	1.89	5.5	0.39	3.5	4.61	15.3	0.41	18.0	0.084	16.3
91905/91580	1.88	6.1	0.38	3.9	4.73	18.3	0.40	20.7	0.081	18.8
91898/91578	1.88	5.8	0.39	3.1	4.55	13.7	0.41	17.2	0.085	14.7
91906/91886	1.83	8.5	0.38	5.7	4.37	9.3	0.42	16.3	0.086	13.8
91907/91884	1.94	3.0	0.40	1.2	4.95	23.8	0.39	21.6	0.080	20.2
91863/91833	2.10	5.2	0.44	9.5	4.45	11.3	0.47	5.5	0.098	1.6
91864/91839	2.07	3.3	0.43	7.1	4.75	18.7	0.44	13.0	0.090	9.8
91904/91579	1.98	0.9	0.41	2.7	4.60	15.0	0.43	13.8	0.089	10.7
91873/91805	2.06	2.9	0.43	7.7	4.49	12.3	0.46	8.4	0.096	4.1
91814/91474	2.20	10.2	0.46	14.8	4.40	10.0	0.50	0.2	0.104	4.4
91867/91842	2.29	14.3	0.47	16.6	4.81	20.3	0.48	4.9	0.097	3.0
91903/91577	1.81	9.7	0.37	7.7	4.59	14.8	0.39	21.3	0.080	19.6
91899/91574	1.82	9.2	0.37	6.6	4.99	24.7	0.36	27.2	0.075	25.1
91872/91583	2.04	1.8	0.42	4.0	4.63	15.7	0.44	12.0	0.090	10.1
91868/91840	2.22	11.2	0.46	13.9	4.41	10.3	0.50	0.8	0.103	3.2
91870/91836	2.11	5.7	0.44	8.8	4.40	10.0	0.48	3.9	0.099	1.1
91866/91835	2.32	15.9	0.48	21.1	4.21	5.2	0.55	10.1	0.115	15.1
91865/91838	2.15	7.3	0.45	11.2	4.44	11.0	0.48	3.3	0.100	0.2
91869/91841	2.05	2.6	0.42	5.2	4.41	10.3	0.47	7.0	0.095	4.6

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EMS Unit/ transducer	CW output power (W)	Deviation from nominal (%)	PW output power (W)	Deviation from nominal (%)	Effective radiating area (cm^2)	Deviation from nominal (%)	CW Effective intensity (W/cm^2)	Deviation from nominal (%)	PW Effective intensity (W/cm^2)	Deviation from nominal (%)
91876/91806	2.11	5.5	0.44	8.9	4.27	6.7	0.49	1.1	0.102	2.1
X 91817/91810	2.28	14.0	0.47	16.4	4.90	(22.4)	0.47	6.9	0.095	4.9
91816/91993	2.06	2.8	0.42	4.9	4.49	12.2	0.46	8.4	0.094	6.5
91871/91575	1.94	3.0	0.40	0.4	4.43	10.7	0.44	12.4	0.090	10.0
91815/91991	2.22	10.9	0.46	15.1	4.37	9.2	0.51	1.6	0.105	5.4
91900/91581	1.88	6.2	0.38	4.9	4.36	9.0	0.43	13.9	0.087	12.8
91874/91809	2.11	5.5	0.44	9.6	4.56	14.0	0.46	7.4	0.096	3.8
X 91901/91576	1.86	7.2	0.38	4.8	4.69	17.3	0.40	(20.9)	0.081	18.9
91875/91803	2.17	8.7	0.45	11.3	4.21	5.3	0.52	3.2	0.106	5.7
91818/91807	2.20	9.8	0.46	13.7	4.17	4.3	0.53	5.2	0.109	9.0
91878/91804	2.24	11.9	0.46	14.0	4.41	10.2	0.51	1.5	0.103	3.4
91820/91808	2.20	9.9	0.46	14.4	4.76	19.0	0.46	7.6	0.096	3.8
91881/91883	2.04	2.1	0.42	5.8	4.19	4.7	0.49	2.4	0.101	1.1
91879/91801	2.21	10.6	0.45	13.3	4.24	6.0	0.52	4.3	0.107	6.9
X 91812/91990	1.97	1.5	0.40	0.3	4.89	(22.3)	0.40	19.4	0.082	18.0
X 91813/91994	2.02	1.0	0.42	4.9	4.98	(24.4)	0.41	18.8	0.084	15.7
91882/91887	2.20	9.9	0.45	12.2	4.22	5.6	0.52	4.1	0.106	6.3
91877/91802	2.08	3.8	0.43	6.5	4.27	6.7	0.49	2.7	0.100	0.2
X 91811/91995	2.24	12.2	0.46	15.7	5.13	(28.2)	0.44	12.5	0.090	9.7

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Continuation Sheet

Reference: U2310

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Reference: U2419
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EMS Unit/ transducer	CW output power (W)	Deviation from nominal (%)	PW output power (W)	Deviation from nominal (%)	Effective radiating area (cm^2)	Deviation from nominal (%)	CW Effective intensity (W/cm^2)	Deviation from nominal (%)	PW Effective intensity (W/cm^2)	Deviation from nominal (%)
91811/92216	2.32	16.0	0.48	20.0	4.72	18.0	0.49	2.0	0.102	2.0
91813/92210	2.21	10.5	0.46	15.0	4.63	15.8	0.48	4.0	0.099	1.0
91867/92002	2.17	8.5	0.45	12.5	4.29	7.3	0.51	2.0	0.105	5.0
91901/91576	2.01	0.5	0.42	5.0	4.29	7.3	0.47	6.0	0.098	2.0
91899/92217	2.18	9.0	0.45	12.5	4.33	8.3	0.50	0.0	0.104	4.0
91903/91577	2.09	4.5	0.42	5.0	4.37	9.3	0.48	4.0	0.096	4.0
91905/91580	2.06	3.0	0.42	5.0	4.63	15.7	0.45	10.0	0.091	9.0
91812/92220	2.19	9.5	0.45	12.5	4.20	5.0	0.52	4.0	0.107	7.0
91866/92212	2.16	8.0	0.44	10.0	4.80	20.0	0.45	10.0	0.092	8.0
91817/92196	2.28	14.0	0.48	20.0	5.04	26.0	0.45	10.0	0.095	5.0
91907/92218	2.21	10.5	0.46	15.0	4.17	4.3	0.53	6.0	0.110	10.0

RESULTS

The nominal values for each parameter based on the specification supplied by the manufacturer are shown below. Two values for the effective intensity of each unit are also provided and these were calculated from the output power (in CW and PW modes) divided by the effective radiating area (ERA).

		Deviation from nominal value	Combined Expanded Uncertainty
Continuous Wave (CW) output power	2.7W	34 %	± 6 %
Pulsed Wave (PW) output power	0.5W	36 %	± 6 %
Effective Radiating Area (ERA)	4.1 cm^2	2.3 %	± 10 %
CW Effective Intensity	0.65 W/cm^2	30 %	± 12 %
PW Effective Intensity	0.13 W/cm^2	30 %	± 12 %

The mean temperature of the water within the balance tank during measurements was between 20.0 °C and 20.1 °C. The uncertainty of this temperature is ±0.5°C.

The reported uncertainty in output power is based on a standard uncertainty multiplied by a coverage factor, k=2, providing a level of confidence of approximately 95%. The reported uncertainty in the effective radiating area is an estimate of the overall uncertainty, based on reference measurements made using a similar experimental arrangement.

UNCERTAINTIES

The uncertainty values quoted in the RESULTS section for the determination of the output power produced by the EMS unit are the expanded overall measurement uncertainties in using the NPL Reference Balance. These are calculated at a confidence level of approximately 95% according to the method recommended in publication M3003 (Edition 1) of the United Kingdom Accreditation Service entitled 'The Expression of Uncertainty and Confidence in Measurement'.

The expanded uncertainty is determined using both type A (random) and type B (systematic) uncertainty evaluations. Type A uncertainty evaluations were calculated from measurements of the EMS unit against the NPL Reference Balance; the transducer was removed from the NPL Reference Balance and repositioned between measurement sets. Type B uncertainty evaluations relate to the measurement of the applied power using the NPL Reference Balance and include components such as the influence of reflections from the tank wall lining and attenuation in the water path between the transducer and the target.

Important note:
This test report applies to the ultrasonic power radiated into a "free-field" environment. The output power may be sensitive to the acoustic load presented to the transducer. When using this unit, particularly in combination with any ultrasound power balance with a membrane, an uncertainty of at least ± 10% should be assigned to the acoustic output power.