Speed of Sound in Pure Water

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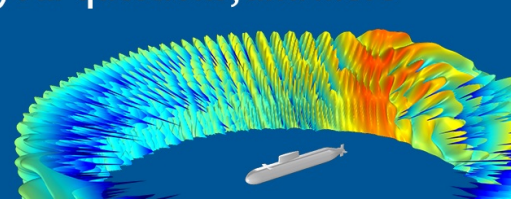

Speed of Sound in Pure Water

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A sound-speed equation of fifth order in temperature is fit with a standard deviation of 0.0028 m/sec to 148 observations between 0.001°C and 95.126°C on the T_{68} scale. The accuracy is believed to be 0.015 m/sec, and the reproducibility over replications is 0.005 m/sec.

Subject Classification: 13.3.

INTRODUCTION

In the course of obtaining a satisfactory sea-water sound-speed equation based on laboratory measurements,[1] data were obtained in pure water[2] with an apparent reproducibility of better than 4 ppm. In this latter reference, it was demonstrated that by comparison of results of reputable observers, the speed of sound in pure water could be specified to better than 0.05 m/sec. Mention was also made therein of indications of an anomaly near 4°C. These measurements, with emphasis about this temperature but extending the total range closer to both 0° and 100°C, are now reported.

I. EXPERIMENTAL METHOD

Sound-speed measurements were made indirectly by means of the ultrasonic interferometer whose construction and operation have been discussed earlier.[1,2] Briefly, acoustic wavelengths are measured by electronically noting some characteristic of a quartz crystal

Table I. Sound speeds measured in pure water for temperatures on T_{68} scale.

Temperature (°C)	Sound speed (m/sec)	Temperature (°C)	Sound speed (m/sec)	Temperature (°C)	Sound speed (m/sec)	Temperature (°C)	Sound speed (m/sec)
0.0010	1402.395	3.4933	1419.287	1.0035	1407.384	7.9894	1439.089
0.0020	1402.398	3.7972	1420.702	1.0035	1407.384	7.9904	1439.094
0.0030	1402.404	3.7982	1420.694	1.0045	1407.392	7.9904	1439.096
0.0030	1402.406	3.7992	1420.700	1.0045	1407.386	7.9904	1439.094
0.0110	1402.445	3.8002	1420.707	1.0055	1407.391	7.9914	1439.102
0.0120	1402.448	3.8002	1420.707	1.0095	1407.412	9.9537	1447.087
0.0130	1402.456	3.9911	1421.584	1.0175	1407.451	9.9537	1447.087
0.0130	1402.453	3.9911	1421.587	1.0235	1407.482	9.9547	1447.094
0.0140	1402.459	3.9921	1421.590	1.0305	1407.516	9.9547	1447.091
0.0520	1402.649	3.9921	1421.589	2.0490	1412.468	9.9547	1447.089
0.0520	1402.652	3.9931	1421.595	2.0560	1412.501	39.9657	1528.809
0.0520	1402.649	4.2160	1422.620	2.0620	1412.527	39.9777	1528.831
0.0530	1402.654	4.2170	1422.624	2.0650	1412.543	39.9887	1528.847
0.0530	1402.654	4.2170	1422.622	2.0680	1412.554	59.9924	1550.980
0.1979	1403.383	4.2170	1422.622	2.0720	1412.574	60.0034	1550.986
0.1979	1403.383	4.5269	1424.032	2.4868	1414.553	60.0124	1550.994
0.1989	1403.390	4.5279	1424.039	2.4868	1414.556	60.0204	1550.998
0.1989	1403.388	4.5279	1424.040	2.4898	1414.573	60.0294	1551.004
0.1989	1403.388	4.5279	1424.039	2.4918	1414.582	70.1190	1554.819
0.4878	1404.829	5.4935	1428.364	2.4928	1414.585	70.1210	1554.819
0.4898	1404.843	5.4935	1428.365	2.9736	1416.861	70.1240	1554.819
0.4908	1404.848	5.4945	1428.367	2.9746	1416.864	70.1340	1554.824
0.4988	1404.888	5.4965	1428.378	2.9766	1416.875	70.1500	1554.824
0.5008	1404.894	5.9892	1430.543	2.9766	1416.876	90.0858	1550.430
0.5018	1404.901	5.9902	1430.548	3.4913	1419.279	90.0868	1550.430
1.0005	1407.365	5.9902	1430.551	3.4913	1419.277	95.1214	1547.096
1.0025	1407.377	5.9922	1430.559	3.4923	1419.277	95.1224	1547.100
1.0025	1407.382	5.9952	1430.572	3.4923	1419.280	95.1264	1547.095

TABLE II. Previous sound-speed measurements in pure water with temperatures converted to T_{68} scale.

Temperature (°C)	Sound speed (m/sec)	Temperature (°C)	Sound speed (m/sec)	Temperature (°C)	Sound speed (m/sec)	Temperature (°C)	Sound speed (m/sec)
0.0560	1402.673	29.9816	1509.081	9.9917	1447.234	49.9956	1542.545
0.0610	1402.695	29.9836	1509.089	9.9957	1447.249	50.0126	1542.563
0.0640	1402.705	34.9710	1519.752	10.0027	1447.276	50.0366	1542.591
0.0680	1402.726	34.9810	1519.768	10.0117	1447.307	50.0466	1542.602
0.0720	1402.747	34.9870	1519.781	19.9196	1482.091	60.0194	1550.999
4.9887	1426.115	39.9727	1528.820	19.9206	1482.096	60.0124	1550.999
4.9917	1426.126	39.9747	1528.823	19.9216	1482.102	73.9957	1555.144
4.9927	1426.129	39.9777	1528.827	24.9815	1496.636	74.0117	1555.144
4.9937	1426.131	39.9847	1528.837	24.9855	1496.646	74.0218	1555.145

TABLE III. Coefficients for Eq. 1 for sound speed in m/sec.

k	Table I fit	Table II fit	Combined fit
0	0.140238689×10^{4}	0.140238749×10^{4}	0.140238754×10^{4}
1	0.503686088×10^{1}	0.503699148×10^{1}	0.503711129×10^{1}
2	$-0.580858499\times10^{-1}$	$-0.580268889\times10^{-1}$	$-0.580852166\times10^{-1}$
3	0.334817140×10^{-3}	0.331767408×10^{-3}	0.334198834×10^{-3}
4	$-0.149252527\times10^{-5}$	$-0.144373838\times10^{-5}$	$-0.147800417\times10^{-5}$
5	0.323913472×10^{-8}	0.298841057×10^{-8}	0.314643091×10^{-8}

TABLE IV. Speed of sound in pure water in m/sec. Calculations from equation fit to 148 measurements between 0.001°C and 95.128°C on T_{68} scale with standard deviation of 0.003 m/sec.

T_{68} °C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
0	1402.388	1402.891	1403.393	1403.893	1404.393	1404.892	1405.389	1405.885	1406.380	1406.874
1	1407.367	1407.859	1408.349	1408.838	1409.327	1409.814	1410.300	1410.784	1411.268	1411.751
2	1412.232	1412.712	1413.192	1413.670	1414.147	1414.622	1415.097	1415.571	1416.043	1416.515
3	1416.985	1417.454	1417.922	1418.389	1418.855	1419.320	1419.784	1420.246	1420.708	1421.168
4	1421.628	1422.086	1422.543	1422.999	1423.454	1423.908	1424.361	1424.813	1425.264	1425.713
5	1426.162	1426.609	1427.056	1427.501	1427.946	1428.389	1428.831	1429.272	1429.712	1430.151
6	1430.589	1431.026	1431.462	1431.897	1432.331	1432.764	1433.196	1433.626	1434.056	1434.485
7	1434.912	1435.339	1435.764	1436.189	1436.612	1437.035	1437.456	1437.877	1438.296	1438.715
8	1439.132	1439.549	1439.964	1440.378	1440.792	1441.204	1441.615	1442.026	1442.435	1442.843
9	1443.251	1443.657	1444.062	1444.467	1444.870	1445.273	1445.674	1446.074	1446.474	1446.872
10	1447.270	1447.666	1448.062	1448.456	1448.850	1449.243	1449.634	1450.025	1450.415	1450.803
11	1451.191	1451.578	1451.964	1452.349	1452.733	1453.116	1453.498	1453.879	1454.259	1454.638
12	1455.016	1455.394	1455.770	1456.145	1456.520	1456.893	1457.266	1457.637	1458.008	1458.378
13	1458.747	1459.115	1459.482	1459.848	1460.213	1460.577	1460.940	1461.303	1461.664	1462.025
14	1462.384	1462.743	1463.101	1463.458	1463.814	1464.169	1464.523	1464.876	1465.229	1465.580
15	1465.931	1466.280	1466.629	1466.977	1467.324	1467.670	1468.015	1468.359	1468.703	1469.045
16	1469.387	1469.728	1470.067	1470.406	1470.745	1471.082	1471.418	1471.754	1472.088	1472.422
17	1472.755	1473.087	1473.418	1473.748	1474.078	1474.406	1474.734	1475.061	1475.386	1475.712
18	1476.036	1476.359	1476.682	1477.003	1477.324	1477.644	1477.963	1478.282	1478.599	1478.916
19	1479.231	1479.546	1479.860	1480.174	1480.486	1480.798	1481.108	1481.418	1481.727	1482.035
20	1482.343	1482.649	1482.955	1483.260	1483.564	1483.868	1484.170	1484.472	1484.772	1485.073
21	1485.372	1485.670	1485.968	1486.264	1486.560	1486.856	1487.150	1487.443	1487.736	1488.028
22	1488.319	1488.610	1488.899	1489.188	1489.476	1489.763	1490.049	1490.335	1490.620	1490.804
23	1491.187	1491.469	1491.751	1492.032	1492.312	1492.591	1492.870	1493.147	1493.424	1493.700
24	1493.976	1494.250	1494.524	1494.797	1495.070	1495.341	1495.612	1495.882	1496.151	1496.420
25	1496.687	1496.954	1497.220	1497.486	1497.751	1498.014	1498.278	1498.540	1498.802	1499.063
26	1499.323	1499.582	1499.841	1500.099	1500.356	1500.612	1500.868	1501.123	1501.377	1501.630
27	1501.883	1502.135	1502.386	1502.637	1502.887	1503.136	1503.384	1503.632	1503.878	1504.124
28	1504.370	1504.615	1504.858	1505.102	1505.344	1505.586	1505.827	1506.067	1506.307	1506.546
29	1506.784	1507.022	1507.258	1507.494	1507.730	1507.964	1508.198	1508.431	1508.664	1508.896
30	1509.127	1509.357	1509.587	1509.816	1510.044	1510.272	1510.499	1510.725	1510.950	1511.175
31	1511.399	1511.623	1511.845	1512.068	1512.289	1512.510	1512.730	1512.949	1513.167	1513.385
32	1513.603	1513.819	1514.035	1514.250	1514.465	1514.679	1514.892	1515.104	1515.316	1515.527
33	1515.738	1515.948	1516.157	1516.365	1516.573	1516.780	1516.987	1517.193	1517.398	1517.602
34	1517.806	1518.009	1518.212	1518.414	1518.615	1518.815	1519.015	1519.214	1519.413	1519.611
35	1519.808	1520.005	1520.201	1520.396	1520.591	1520.785	1520.978	1521.171	1521.363	1521.554
36	1521.745	1521.935	1522.125	1522.314	1522.502	1522.690	1522.877	1523.063	1523.249	1523.434
37	1523.618	1523.802	1523.985	1524.168	1524.350	1524.531	1524.712	1524.892	1525.071	1525.250
38	1525.428	1525.606	1525.783	1525.959	1526.135	1526.310	1526.484	1526.658	1526.832	1527.004
39	1527.176	1527.348	1527.518	1527.689	1527.858	1528.027	1528.195	1528.363	1528.530	1528.697

TABLE IV. (*continued*)

T_{68} °C	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
40	1528.863	1529.028	1529.193	1529.357	1529.521	1529.684	1529.846	1530.008	1530.169	1530.329
41	1530.489	1530.649	1530.807	1530.965	1531.123	1531.280	1531.436	1531.592	1531.747	1531.902
42	1532.056	1532.210	1532.362	1532.515	1532.666	1532.818	1532.968	1533.118	1533.267	1533.416
43	1533.564	1533.712	1533.859	1534.006	1534.152	1534.297	1534.442	1534.586	1534.730	1534.873
44	1535.015	1535.157	1535.298	1535.439	1535.579	1535.719	1535.858	1535.997	1536.134	1536.272
45	1536.409	1536.545	1536.681	1536.816	1536.950	1537.084	1527.218	1537.351	1537.483	1537.615
46	1537.746	1537.877	1538.007	1538.137	1538.266	1538.394	1538.522	1538.650	1538.776	1538.903
47	1539.028	1539.154	1539.278	1539.402	1539.526	1539.649	1539.772	1539.894	1540.015	1540.136
48	1540.256	1540.376	1540.495	1540.614	1540.732	1540.850	1540.967	1541.083	1541.199	1541.315
49	1541.430	1541.544	1541.658	1541.772	1541.885	1541.997	1542.109	1542.220	1542.331	1542.441
50	1542.551	1542.660	1542.768	1542.877	1542.984	1543.091	1543.198	1543.304	1543.409	1543.514
51	1543.619	1543.723	1543.826	1543.929	1544.032	1544.134	1544.235	1544.336	1544.436	1544.536
52	1544.636	1544.734	1544.833	1544.931	1545.028	1545.125	1545.221	1545.317	1545.412	1545.507
53	1545.601	1545.695	1545.788	1545.881	1545.973	1546.065	1546.156	1546.247	1546.337	1546.427
54	1546.517	1546.605	1546.694	1546.781	1546.869	1546.955	1547.042	1547.128	1547.213	1547.298
55	1547.382	1547.466	1547.549	1547.632	1547.715	1547.796	1547.878	1547.959	1548.039	1548.119
56	1548.199	1548.278	1548.356	1548.434	1548.512	1548.589	1548.665	1548.741	1548.717	1548.892
57	1548.967	1549.041	1549.115	1549.188	1549.260	1549.333	1549.405	1549.476	1549.547	1549.617
58	1549.687	1549.756	1549.825	1549.894	1549.962	1550.029	1550.096	1550.163	1550.229	1550.295
59	1550.360	1550.425	1550.489	1550.553	1550.616	1550.679	1550.741	1550.803	1550.865	1550.926
60	1550.986	1551.046	1551.106	1551.165	1551.224	1551.282	1551.340	1551.397	1551.454	1551.510
61	1551.566	1551.622	1551.677	1551.731	1551.786	1551.839	1551.892	1551.945	1551.998	1552.049
62	1552.101	1552.152	1552.202	1552.252	1552.302	1552.351	1552.400	1552.448	1552.496	1552.543
63	1552.590	1552.637	1552.683	1552.729	1552.774	1552.818	1552.863	1552.907	1552.950	1552.993
64	1553.035	1553.078	1553.119	1553.160	1553.201	1553.241	1553.281	1553.321	1553.360	1553.398
65	1553.437	1553.474	1553.512	1553.548	1553.585	1553.621	1553.656	1553.691	1553.726	1553.760
66	1553.794	1553.828	1553.860	1553.893	1553.925	1553.957	1553.988	1554.019	1554.049	1554.079
67	1554.109	1554.138	1554.167	1554.195	1554.223	1554.250	1554.277	1554.304	1554.330	1554.356
68	1554.381	1554.406	1554.430	1554.454	1554.478	1554.501	1554.524	1554.546	1554.568	1554.590
69	1554.611	1554.632	1554.652	1554.672	1554.691	1554.710	1554.729	1554.747	1554.765	1554.782
70	1554.799	1554.816	1554.832	1554.848	1554.863	1554.878	1554.893	1554.907	1554.920	1554.934
71	1554.947	1554.959	1554.971	1554.983	1554.994	1555.005	1555.015	1555.026	1555.035	1555.044
72	1555.053	1555.062	1555.070	1555.077	1555.085	1555.091	1555.098	1555.104	1555.110	1555.115
73	1555.120	1555.124	1555.128	1555.132	1555.135	1555.138	1555.140	1555.142	1555.144	1555.145
74	1555.146	1555.147	1555.147	1555.146	1555.146	1555.145	1555.143	1555.141	1555.139	1555.136
75	1555.133	1555.130	1555.126	1555.122	1555.117	1555.112	1555.107	1555.101	1555.095	1555.088
76	1555.081	1555.074	1555.066	1555.058	1555.050	1555.041	1555.032	1555.022	1555.012	1555.002
77	1554.991	1554.980	1554.968	1554.956	1554.944	1554.931	1554.918	1554.905	1554.891	1554.877
78	1554.862	1554.847	1554.832	1554.816	1554.800	1554.784	1554.767	1554.750	1554.732	1554.714
79	1554.696	1554.677	1554.658	1554.639	1554.619	1554.599	1554.578	1554.557	1554.536	1554.514
80	1554.492	1554.470	1554.447	1554.424	1554.400	1554.376	1554.352	1554.327	1554.302	1554.277
81	1554.251	1554.225	1554.199	1554.172	1554.144	1554.117	1554.089	1554.061	1554.032	1554.003
82	1553.974	1553.944	1553.914	1553.883	1553.852	1553.821	1553.789	1553.758	1553.725	1553.693
83	1553.660	1553.626	1553.592	1553.558	1553.524	1553.489	1553.454	1553.418	1553.383	1553.346
84	1553.310	1553.273	1553.235	1553.198	1553.160	1553.121	1553.083	1553.044	1553.004	1552.964
85	1552.924	1552.884	1552.843	1552.802	1552.760	1552.718	1552.676	1552.634	1552.591	1552.547
86	1552.504	1552.460	1552.415	1552.371	1552.326	1552.280	1552.234	1552.188	1552.142	1552.095
87	1552.048	1552.001	1551.953	1551.905	1551.856	1551.807	1551.758	1551.709	1551.659	1551.609
88	1551.558	1551.507	1551.456	1551.404	1551.352	1551.300	1551.248	1551.195	1551.141	1551.088
89	1551.034	1550.980	1550.925	1550.870	1550.815	1550.759	1550.703	1550.647	1550.590	1550.533
90	1550.476	1550.418	1550.360	1550.302	1550.243	1550.184	1550.125	1550.065	1550.005	1549.945
91	1549.884	1549.823	1549.762	1549.700	1549.638	1549.576	1549.513	1549.450	1549.387	1549.323
92	1549.259	1549.195	1549.131	1549.066	1549.000	1548.935	1548.869	1548.803	1548.736	1548.669
93	1548.602	1548.534	1548.467	1548.398	1548.330	1548.261	1548.192	1548.122	1548.053	1547.983
94	1547.912	1547.841	1547.770	1547.699	1547.627	1547.555	1547.483	1547.410	1547.337	1547.264
95	1547.190	1547.116	1547.042	1546.967	1546.892	1546.817	1546.741	1546.665	1546.589	1546.513
96	1546.436	1546.359	1546.281	1546.204	1546.126	1546.047	1545.969	1545.890	1545.810	1545.731
97	1545.651	1545.570	1545.490	1545.409	1545.328	1545.246	1545.164	1545.082	1545.000	1544.917
98	1544.834	1544.751	1544.667	1544.583	1544.499	1544.414	1544.329	1544.244	1544.159	1544.073
99	1543.987	1543.900	1543.814	1543.727	1543.639	1543.552	1543.464	1543.376	1543.287	1543.198
100	1543.109									

operated in a continuous wave iterative-reflection technique and counting these imposed characteristics as the reflector–source separation is varied. The path change for some 300 acoustic fringes at 5 MHz is measured by a laser interferometer. Consideration of all sources of error, including theoretical predictions[3,4] leads to a specification of accuracy of 10 ppm or 0.015 m/sec.

II. DATA

Some 112 new data points for the speed of sound in pure water were taken in 1970 and are reported in

Table I, with temperatures on the T_{68} scale. In Table II, the previous measurements[2] are repeated with temperatures converted to the same scale. The results of these calculations are given to the nearest 0.0001°C, although the measurements were made to only 0.001°C, to facilitate conversion.

III. EQUATION DEVELOPMENT

To ascertain whether these two data sets are compatible, separate least-squares fits were made[5] at the Naval Undersea Research and Development Center (NAVUSEARANDCEN). A fifth-degree polynomial was found satisfactory for both, viz:

$$C=\sum_{i=0}^{5} k_i T^i. \quad (1)$$

The 36 earlier observations in Table II over the temperature range $0.056°C \leq T_{68} \leq 74.022°C$ were fit with a standard deviation of 0.0025 m/sec and coefficients as given in the third column of Table III.

The least-squares fit to the 112 data points of Table I over the larger temperature range $0.001°C \leq T_{68} \leq 95.126°C$, but with emphasis between 0° and 10°C has a standard deviation of 0.0026 m/sec and comparable coefficients as given in column two of Table III.

Because of the close agreement between these expressions, Tables I and II were combined, and a least-squares fit was obtained to all 148 observations with a standard deviation of 0.0029 m/sec and coefficients as given in the last column of Table III.

TABLE V. Regression curve deviation average and scatter for nominal experimental temperatures.

Nominal T (°C)	Average (m/sec)	Scatter (m/sec)
Second data set		
0.01	−0.002	0.003
0.05	0.000	0.000
0.2	−0.001	0.000
0.5	−0.001	0.004
1.0	+0.001	0.006
2.0	+0.002	0.004
2.5	+0.004	0.006
3.0	0.000	0.002
3.5	+0.004	0.006
3.8	+0.003	0.004
4.0	+0.002	0.002
4.2	−0.002	0.002
4.5	−0.004	0.002
5.5	−0.004	0.002
6.0	−0.003	0.004
8.0	−0.003	0.004
10.0	−0.001	0.004
40.0	−0.004	0.002
60.0	+0.001	0.002
70.0	0.000	0.004
90.0	−0.004	0.000
95.0	+0.002	0.004
First data set		
0.06	+0.001	0.006
5.0	−0.001	0.006
10.0	+0.005	0.006
20.0	+0.003	0.002
25.0	+0.002	0.000
30.0	+0.002	0.003
35.0	+0.001	0.004
40.0	−0.001	0.002
50.0	0.000	0.002
60.0	0.000	0.001
74.0	+0.002	0.001

TABLE VI. Temperature scale conversion.

T_{48} (°C)	T_{68} (°C)	$T_{48}-T_{68}$ (°C)	T_{48} (°C)	T_{68} (°C)	$T_{48}-T_{68}$ (°C)	T_{48} (°C)	T_{68} (°C)	$T_{48}-T_{68}$ (°C)	T_{48} (°C)	T_{68} (°C)	$T_{48}-T_{68}$ (°C)
0	0	0	26	25.9913	0.0087	51	50.9897	0.0103	76	75.9932	0.0068
1	0.9995	0.0005	27	26.9911	0.0089	52	51.9897	0.0103	77	76.9934	0.0066
2	1.9990	0.0010	28	27.9909	0.0091	53	52.9898	0.0102	78	77.9937	0.0063
3	2.9986	0.0014	29	28.9908	0.0092	54	53.9899	0.0101	79	78.9939	0.0061
4	3.9981	0.0019	30	29.9907	0.0093	55	54.9899	0.0101	80	79.9941	0.0059
5	4.9977	0.0023	31	30.9905	0.0095	56	55.9900	0.0100	81	80.9944	0.0056
6	5.9973	0.0027	32	31.9904	0.0096	57	56.9901	0.0099	82	81.9946	0.0054
7	6.9969	0.0031	33	32.9902	0.0098	58	57.9902	0.0098	83	82.9949	0.0051
8	7.9965	0.0035	34	33.9901	0.0099	59	58.9903	0.0097	84	83.9952	0.0048
9	8.9961	0.0039	35	34.9900	0.0100	60	59.9904	0.0096	85	84.9954	0.0046
10	9.9957	0.0043	36	35.9899	0.0101	61	60.9906	0.0094	86	85.9957	0.0043
11	10.9953	0.0047	37	36.9898	0.0102	62	61.9907	0.0093	87	86.9960	0.0040
12	11.9950	0.0050	38	37.9898	0.0102	63	62.9908	0.0092	88	87.9963	0.0037
13	12.9946	0.0054	39	38.9897	0.0103	64	63.9910	0.0090	89	88.9965	0.0035
14	13.9943	0.0057	40	39.9897	0.0103	65	64.9911	0.0089	90	89.9968	0.0032
15	14.9940	0.0060	41	40.9896	0.0104	66	65.9913	0.0087	91	90.9971	0.0029
16	15.9937	0.0063	42	41.9896	0.0104	67	66.9914	0.0086	92	91.9974	0.0026
17	16.9934	0.0066	43	42.9896	0.0104	68	67.9916	0.0084	93	92.9977	0.0023
18	17.9931	0.0069	44	43.9895	0.0105	69	68.9918	0.0082	94	93.9981	0.0019
19	18.9929	0.0071	45	44.9895	0.0105	70	69.9920	0.0080	95	94.9984	0.0016
20	19.9926	0.0074	46	45.9895	0.0105	71	70.9922	0.0078	96	95.9987	0.0013
21	20.9924	0.0076	47	46.9895	0.0105	72	71.9923	0.0077	97	96.9990	0.0010
22	21.9921	0.0079	48	47.9986	0.0104	73	72.9925	0.0075	98	97.9993	0.0007
23	22.9919	0.0081	49	48.9896	0.0104	74	73.9928	0.0072	99	98.9997	0.0003
24	23.9917	0.0083	50	49.9896	0.0104	75	74.9930	0.0070	100	100.0000	0
25	24.9915	0.0085									

This equation fit to the combined data predicts a sound-speed maximum of 1555.147 m/sec at a temperature of 74.172°C on the T_{68} scale. Sound speeds calculated with these coefficients are given in Table IV for tenth-degree celsius intervals. A rounding off of these coefficients is employed at NAVUSEARANDCEN for velocimeter calibrations.[6]

IV. DISCUSSION OF RESULTS

The standard deviation of the equation fit to the data is 0.003 m/sec or 2 ppm. As stated, the measurements are most probably accurate to 0.015 m/sec. Another measure of the precision of the data (apart from accuracy) in the form of reproducibility over replications can be obtained from Table V, which lists the average regression deviation and scatter thereof, for nominal experimental temperatures. It is tempting to postulate the existence of anomalies not only about 4°C but also at 40° and 90°C, but such an assertion is strongly resisted since the deviations are of the order of the scatter and standard deviation. Comparison of the present results may be made to other work[7] of lesser precision (standard deviation five times larger) and greater scatter (twenty times larger) where relative measurements over a smaller temperature range ($6°C \leq T \leq 81°C$) showed "no significant discontinuities or other anomalous behavior." These latter authors found an eighth-order polynomial was required to fit their data, and they ignored a deviation three times greater than their scatter.

In light of the above, this present data is presented simply as the most precise and hopefully accurate values of sound speed in pure water.

A temperature scale conversion table is presented in Table VI to assist those still operating on the T_{48} scale.

[1] V. A. Del Grosso and C. W. Mader, J. Acoust. Soc. Amer. (in press, 1972).
[2] V. A. Del Grosso, J. Acoust. Soc. Amer. **47**, 947–949 (1970).
[3] V. A. Del Grosso, J. Acoust. Soc. Amer. **48**, 770–771 (1970).
[4] V. A. Del Grosso, Acustica **24**, 299–311 (1971).
[5] K. V. Mackenzie, private comunication (January 1971).
[6] K. V. Mackenzie, private communication (February 1971). Also, see J. Acoust. Soc. Amer. **50**, 1321–1333 (1971).
[7] W. Senghaphram, G. O. Zimmerman, and C. E. Chase, J. Chem. Phys. **51**, 2543–2545 (1969).