Determination of Dry Coating

Determination of Dry Coating													
	A	B	C	D	E	F	G	H	I	J	K	L	M
Water Droplet Test													
Seconds													
Sample 1 (red)	0.000	1.000	300	0	1	3	0	4	25	300	300	29	300
Sample 2 (green)	0.000	0.000	300	0	1	4	0	5	62	300	300	51	300
Sample 3 (blue)	0.000	1.000	300	0	1	4	0	6	65	300	300	28	300
Sample 4 (black)	0.000	1.000	300	0	1	3	0	8	85	300	300	45	300
Sample 5 (orange)	0.000	1.000	300	0	1	4	0	7	49	300	300	39	300
Float Test													
Sample Length	12" (304.8mm) Ends Sealed												
Seconds afloat													
Sample 1 (red)	5.000	5.000		8	7	15	4	18	3100			95	
Sample 2 (green)											12600		97200
Sample 3 (blue)											14400		
Sample 4 (black)													165600
Sample 5 (orange)													
FED-STD-191A (6011)													
Sample Length	15" (381mm) with marks 3" (76mm) from each end. Measured @ 1% of load.												
Initial Weight													
Sample 1 (red)	28.569	27.627	27.201	28.029	28.281	28.733	28.098	28.178	29.512	29.766	29.588	31.356	31.152
Sample 2 (green)	28.561	27.327	27.190	28.023	27.635	29.330	27.855	28.115	29.675	30.385	29.698	31.320	31.589
Sample 3 (blue)	28.428	26.999	27.205	28.144	28.926	29.364	27.763	28.232	29.523	30.070	29.695	31.766	30.995
24 hours													
9/15													
Final Weight													
Sample 1 (red)	24.013	23.265	19.840	23.837	23.536	23.794	23.818	23.910	25.250	22.735	25.786	28.233	27.511
Sample 2 (green)	24.662	23.517	19.413	24.083	22.842	24.708	23.353	24.109	25.439	23.179	25.847	28.301	27.844
Sample 3 (blue)	24.117	23.178	19.707	24.245	23.812	24.340	23.114	23.867	25.512	23.550	26.299	29.194	26.760
1 Hour Immersion													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.510	14.605	14.291	13.689	15.770	14.998	14.991	14.476	15.729	15.777	15.483	16.515	16.306
Sample 2 (green)	15.271	14.591	14.708	14.204	15.550	15.448	14.777	14.675	15.552	15.763	15.556	16.607	16.270
Sample 3 (blue)	15.145	14.473	14.551	13.489	15.490	15.171	14.736	14.529	15.683	15.656	15.456	16.551	16.551
Sample 4 (black)	15.344	14.601	14.543	14.577	15.605	15.361	14.916	14.822	15.445	15.941	15.671	16.543	16.424
Sample 5 (orange)	16.036	14.480	14.355	14.542	15.358	15.371	14.816	14.501	15.646	15.771	15.608	16.621	16.224
Final Weight													
Sample 1 (red)	21.731	21.103	14.785	19.800	22.005	21.014	21.161	20.665	22.463	16.165	19.850	25.141	16.917
Sample 2 (green)	22.233	20.889	15.032	20.426	21.890	21.563	21.025	20.959	22.224	16.227	20.398	25.139	17.441
Sample 3 (blue)	21.833	20.717	14.961	19.637	21.727	21.244	21.019	20.974	22.335	16.195	20.044	25.282	17.551
Sample 4 (black)	22.569	21.454	14.959	21.181	21.952	21.748	21.495	21.411	22.351	16.557	20.455	25.014	17.757
Sample 5 (orange)	23.700	20.886	14.763	20.843	21.457	21.446	20.967	20.710	22.581	16.284	20.379	25.132	17.437
2 Hour Immersion													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.294	14.419	14.415	13.608	15.386	15.591	14.953	14.710	15.598	15.844	15.510	16.440	16.393
Sample 2 (green)	15.268	14.464	14.332	14.017	15.307	15.239	14.779	14.427	15.247	15.703	15.292	16.376	16.392
Sample 3 (blue)	15.082	14.587	14.366	13.548	15.292	15.153	14.943	14.612	15.443	15.705	15.414	16.643	16.424
Sample 4 (black)	15.415	14.497	14.284	14.706	15.439	15.120	14.737	14.312	15.479	15.655	15.385	16.276	16.201
Sample 5 (orange)	15.116	14.369	14.585	14.621	15.284	15.263	14.764	14.473	15.625	15.757	15.522	16.403	16.241
Final Weight													
Sample 1 (red)	22.156	20.479	14.935	21.104	21.579	21.937	21.310	19.776	22.612	16.517	20.430	25.220	17.679
Sample 2 (green)	22.058	21.080	14.781	20.336	21.648	21.268	20.917	20.532	21.795	16.340	21.001	24.589	18.063
Sample 3 (blue)	22.140	21.190	14.944	19.812	21.642	21.165	21.328	21.150	22.606	16.321	21.375	25.225	18.054
Sample 4 (black)	22.965	21.281	14.850	21.532	21.984	21.230	21.061	20.421	22.619	16.490	21.030	25.035	17.831
Sample 5 (orange)	22.169	20.986	15.181	21.216	21.772	21.464	21.045	20.678	22.986	16.587	21.411	25.188	18.248
4 Hour Immersion													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.204	14.495	14.590	14.796	15.512	15.351	14.850	14.771	15.613	15.840	15.155	16.838	16.630
Sample 2 (green)	15.406	14.638	14.500	14.560	15.328	15.392	14.951	14.694	15.711	15.502	15.656	16.652	16.500
Sample 3 (blue)	15.101	14.616	14.576	14.713	15.435	15.051	14.789	14.671	15.544	15.743	15.761	16.768	16.299
Sample 4 (black)	15.215	14.510	14.477	14.718	15.514	15.115	14.771	14.567	15.514	15.853	15.617	16.521	16.431
Sample 5 (orange)	15.140	14.609	14.331	14.545	15.571	15.231	14.980	14.637	15.693	15.867	15.470	16.581	16.345

Determination of Dry Coating													
	A	B	C	D	E	F	G	H	I	J	K	L	M
Final Weight													
Sample 1 (red)	22.056	21.124	15.613	21.415	21.730	21.123	21.201	21.629	22.786	16.832	19.884	25.505	19.667
Sample 2 (green)	22.534	21.404	15.240	20.984	21.738	21.283	21.011	21.655	23.029	16.166	21.340	25.272	19.644
Sample 3 (blue)	22.001	21.285	15.358	21.307	22.001	21.262	20.940	20.802	22.344	16.526	20.261	25.392	19.263
Sample 4 (black)	22.011	20.973	15.076	21.224	21.910	21.071	20.994	21.025	22.438	16.635	20.548	25.164	19.805
Sample 5 (orange)	22.305	21.376	14.975	21.209	22.148	21.816	21.475	21.072	22.793	16.548	21.317	25.200	18.910
24 Hour Immersion													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.505	14.358	14.301	13.538	15.189	14.787	14.783	14.494	15.526	15.626	15.478	16.246	16.315
Sample 2 (green)	15.165	14.212	14.627	14.651	15.328	15.411	14.851	14.607	15.463	15.648	15.364	16.464	16.226
Sample 3 (blue)	14.853	14.467	14.324	13.544	15.389	15.454	15.011	14.592	15.405	15.837	15.245	16.307	16.141
Sample 4 (black)	15.048	14.240	14.385	14.712	15.403	15.302	14.877	14.261	15.468	15.758	15.454	16.374	16.368
Sample 5 (orange)	15.080	14.427	14.420	14.189	15.235	15.220	14.908	14.483	15.358	15.748	15.410	16.342	16.162
Final Weight													
Sample 1 (red)	22.789	21.530	15.289	20.078	21.680	21.013	21.448	20.927	22.769	17.100	22.598	24.541	21.240
Sample 2 (green)	23.209	21.320	16.068	21.409	21.857	22.229	21.575	21.069	22.676	16.787	22.388	25.265	22.876
Sample 3 (blue)	22.270	21.543	15.123	20.009	22.101	22.121	21.864	21.111	22.469	17.304	20.988	24.849	21.747
Sample 4 (black)	22.586	21.344	15.319	21.633	21.959	21.811	21.627	20.726	22.760	17.111	21.230	25.233	22.690
Sample 5 (orange)	22.610	22.061	15.356	20.879	21.997	22.053	21.708	21.186	22.763	17.186	21.273	25.274	22.534
48 Hour Immersion													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.374	14.395	14.407	14.478	13.552	13.420	13.042	14.736	15.660	15.650	15.388	16.594	16.457
Sample 2 (green)	15.128	14.407	14.296	14.637	15.810	15.568	14.992	14.739	15.471	15.779	15.733	16.444	16.479
Sample 3 (blue)	15.121	14.615	14.447	14.503	15.640	15.505	14.789	14.954	15.451	15.862	15.356	16.724	16.463
Sample 4 (black)	15.245	14.334	14.389	13.524	15.590	15.397	14.974	14.682	15.435	15.820	15.483	16.505	16.500
Sample 5 (orange)	15.105	14.339	14.318	14.501	15.404	14.919	14.940	14.613	15.475	15.813	15.522	16.507	16.507
Final Weight													
Sample 1 (red)	23.049	21.501	15.296	21.003	22.082	22.070	21.786	21.400	22.980	17.220	21.522	25.484	22.303
Sample 2 (green)	22.361	21.254	15.251	21.201	22.265	22.140	21.660	21.411	22.860	17.107	21.601	25.215	23.204
Sample 3 (blue)	22.773	22.080	15.476	21.212	22.192	22.338	21.537	21.719	22.984	17.472	22.321	25.739	23.635
Sample 4 (black)	23.294	21.561	15.518	20.078	22.206	22.200	21.724	21.825	23.043	17.884	22.722	25.600	21.512
Sample 5 (orange)	22.454	21.701	15.713	21.392	22.021	21.410	21.670	21.245	23.154	17.725	21.596	25.388	23.412
72 Hour Immersion													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.509	14.598	14.654	14.642	15.433	15.365	14.857	14.740	15.830	15.892	15.674	16.542	16.507
Sample 2 (green)	15.375	14.703	14.860	13.630	15.528	15.583	15.033	14.830	15.782	15.958	15.505	16.661	16.348
Sample 3 (blue)	15.279	14.543	14.515	14.822	15.622	15.787	15.025	14.746	15.829	15.970	15.710	16.726	16.555
Sample 4 (black)	15.229	14.522	14.566	14.635	15.549	15.627	15.033	14.496	15.531	16.069	15.462	16.357	16.304
Sample 5 (orange)	15.364	14.693	14.635	14.619	15.526	15.557	15.032	14.719	15.673	16.105	15.372	16.561	16.343
Final Weight													
Sample 1 (red)	23.896	22.328	16.718	21.826	22.522	22.353	22.083	21.707	24.163	19.294	23.495	25.803	23.506
Sample 2 (green)	23.647	22.479	16.586	20.464	22.184	22.855	21.855	21.879	23.613	18.678	21.956	25.639	23.377
Sample 3 (blue)	22.423	22.005	16.403	21.558	22.478	22.860	21.948	21.556	23.712	20.633	22.918	25.739	23.463
Sample 4 (black)	23.288	21.974	16.568	21.500	22.170	22.535	21.992	21.181	19.019	23.088	21.662	24.985	23.056
Sample 5 (orange)	23.306	22.122	16.816	21.383	22.136	22.339	22.048	21.420	19.798	23.332	21.732	24.913	23.037
German Military Standard Test TL 4020-0015 (BWB) Dynamic Ropes - Method B													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.434	14.587	14.510	14.792	15.710	15.581	14.810	14.788	15.592	16.043	15.422	16.521	16.395
Sample 2 (green)	15.276	14.718	14.377	14.584	15.541	15.265	14.930	14.475	15.515	15.834	15.475	16.376	16.372
Sample 3 (blue)	15.367	14.681	14.372	13.598	15.625	15.590	14.859	14.448	15.915	15.998	15.325	16.666	16.531
Sample 4 (black)	15.278	14.562	14.850	13.908	15.547	15.601	15.101	14.716	15.555	15.857	15.668	16.542	16.505
Sample 5 (orange)	15.344	14.554	14.685	14.838	15.430	15.449	14.855	14.872	15.783	15.780	15.508	16.294	16.657
Final Weight													
Sample 1 (red)	22.660	21.471	16.942	21.285	22.144	22.113	21.335	21.200	23.108	18.689	22.308	24.673	22.942
Sample 2 (green)	22.525	21.639	16.004	20.937	21.155	21.653	21.501	21.244	22.775	18.222	21.580	24.349	22.786
Sample 3 (blue)	22.391	21.509	15.828	19.563	21.880	22.051	21.642	20.645	23.347	18.797	21.616	24.295	22.881
Sample 4 (black)	22.338	21.375	17.025	19.630	21.728	22.149	21.727	21.033	23.001	14.083	22.177	24.244	22.879
Sample 5 (orange)	22.356	20.949	16.389	20.630	21.505	21.494	21.154	21.055	23.094	19.146	21.570	23.866	22.826

Determination of Dry Coating

Determination of Dry Coating													
	A	B	C	D	E	F	G	H	I	J	K	L	M
1 Hour Immersion	After wash												
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.122	14.393	14.356	13.538	15.206	14.699	14.718	14.508	15.476	15.658	15.500	16.272	16.351
Sample 2 (green)	15.090	14.176	14.630	14.592	15.374	15.307	14.736	14.543	15.462	15.579	15.336	16.456	16.264
Sample 3 (blue)	14.870	14.418	14.344	13.540	15.407	15.380	14.919	14.544	15.433	15.860	15.243	16.288	16.180
Sample 4 (black)	15.013	14.178	14.411	14.780	15.441	15.246	14.780	14.292	15.530	15.929	15.488	16.377	16.413
Sample 5 (orange)	15.029	14.358	14.505	14.182	15.253	15.199	14.853	14.477	15.385	15.755	15.392	16.429	16.275
Final Weight													
Sample 1 (red)	24.348	22.942	14.965	20.619	19.737	17.009	23.310	15.395	23.731	16.639	17.666	25.046	17.858
Sample 2 (green)	24.465	22.835	15.865	20.891	21.139	18.004	23.052	15.916	22.755	16.661	17.292	24.740	17.609
Sample 3 (blue)	24.069	23.119	15.106	20.575	20.079	17.742	22.989	15.531	23.009	16.828	17.063	25.657	17.220
Sample 4 (black)	24.088	22.867	15.509	20.481	19.006	17.861	23.057	15.743	23.264	16.919	17.239	24.722	17.603
Sample 5 (orange)	24.255	23.267	15.268	20.041	21.739	21.828	23.101	16.260	23.422	16.909	18.162	25.064	17.897
Shower Test													
Sample Length	200mm - Sealed												
Initial Weight													
Sample 1 (red)	15.242	14.918	14.393	14.739	15.932	15.436	15.089	14.803	15.653	15.747	15.288	16.303	16.364
Sample 2 (green)	15.285	14.978	14.385	14.663	15.553	15.499	14.856	14.613	15.468	15.640	15.659	16.405	16.481
Sample 3 (blue)	15.216	15.056	14.347	13.816	15.635	15.182	14.556	14.607	15.595	15.709	15.380	16.333	16.542
Sample 4 (black)	15.286	14.621	14.336	14.798	15.735	15.311	14.921	14.752	15.520	15.024	15.497	16.620	16.479
Final Weight													
Sample 1 (red)	22.137	22.042	16.024	21.458	22.411	21.668	21.377	20.976	22.770	16.855	18.448	24.580	17.616
Sample 2 (green)	21.928	22.236	15.836	21.314	21.881	21.627	21.042	20.655	22.439	16.816	18.512	24.466	17.778
Sample 3 (blue)	22.175	21.787	16.099	20.189	21.981	21.400	20.703	20.726	22.803	16.654	18.621	24.288	17.911
Sample 4 (black)	22.543	21.369	16.136	21.306	22.097	21.289	21.284	20.814	22.618	16.892	18.570	24.720	17.554

Determination of Dry Coating													
	A	B	C	D	E	F	G	H	I	J	K	L	M
Water Droplet Test													
Seconds													
Sample 1 (red)	0	1	300	0	1	3	0	4	25	300	300	29	300
Sample 2 (green)	0	0	300	0	1	4	0	5	62	300	300	51	300
Sample 3 (blue)	0	1	300	0	1	4	0	6	65	300	300	28	300
Sample 4 (black)	0	1	300	0	1	3	0	8	85	300	300	45	300
Sample 5 (orange)	0	1	300	0	1	4	0	7	49	300	300	39	300
Float Test													
Sample Length	12" (304.8mm) Ends Sealed												
Seconds afloat													
Sample 1 (red)	5	5		8	7	15	4	18	3100			95	
Sample 2 (green)											12600		97200
Sample 3 (blue)											14400		
Sample 4 (black)													165600
Sample 5 (orange)													
FED-STD-191A (6011)													
Sample Length	15" (381mm) with marks 3" (76mm) from each end. Measured @ 1% of load.												
Initial Weight													
Sample 1 (red)	0.40	0.40	0.22	0.42	0.39	0.38	0.41	0.41	0.43	0.27	0.45	0.50	0.47
Sample 2 (green)	0.44	0.43	0.19	0.43	0.38	0.40	0.40	0.43	0.43	0.27	0.45	0.51	0.47
Sample 3 (blue)	0.41	0.43	0.21	0.44	0.37	0.38	0.39	0.41	0.44	0.31	0.48	0.53	0.44
Average Change	0.42	0.42	0.20	0.43	0.38	0.39	0.40	0.42	0.43	0.28	0.46	0.51	0.46
Std Dev.	0.019	0.017	0.013	0.010	0.008	0.013	0.013	0.010	0.008	0.019	0.014	0.017	0.018
%Std Dev	0.04654	0.03985	0.06413	0.02279	0.02004	0.03448	0.03186	0.02512	0.01751	0.06752	0.03089	0.03237	0.03969
1 Hour Immersion													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.40	0.44	0.03	0.45	0.40	0.40	0.41	0.43	0.43	0.02	0.28	0.52	0.04
Sample 2	0.46	0.43	0.02	0.44	0.41	0.40	0.42	0.43	0.43	0.03	0.31	0.51	0.07
Sample 3	0.44	0.43	0.03	0.46	0.40	0.40	0.43	0.44	0.42	0.03	0.30	0.53	0.06
Sample 4	0.47	0.47	0.03	0.45	0.41	0.42	0.44	0.44	0.45	0.04	0.31	0.51	0.08
Sample 5	0.48	0.44	0.03	0.43	0.40	0.40	0.42	0.43	0.44	0.03	0.31	0.51	0.07
Average Change	0.45	0.44	0.03	0.45	0.40	0.40	0.42	0.43	0.43	0.03	0.30	0.52	0.07
Std Dev.	0.030	0.015	0.004	0.010	0.006	0.008	0.012	0.009	0.010	0.005	0.011	0.007	0.017
%Std Dev	0.06776	0.03484	0.15642	0.02153	0.01381	0.02072	0.02716	0.02032	0.02342	0.16553	0.03793	0.01355	0.26403
2 Hour Immersion													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.45	0.42	0.04	0.55	0.40	0.41	0.43	0.34	0.45	0.04	0.32	0.53	0.08
Sample 2	0.44	0.46	0.03	0.45	0.41	0.40	0.42	0.42	0.43	0.04	0.37	0.50	0.10
Sample 3	0.47	0.45	0.04	0.46	0.42	0.40	0.43	0.45	0.46	0.04	0.39	0.52	0.10
Sample 4	0.49	0.47	0.04	0.46	0.42	0.40	0.43	0.43	0.46	0.05	0.37	0.54	0.10
Sample 5	0.47	0.46	0.04	0.45	0.42	0.41	0.43	0.43	0.47	0.05	0.38	0.54	0.12
Average Change	0.46	0.45	0.04	0.48	0.42	0.40	0.42	0.41	0.46	0.05	0.36	0.52	0.10
Std Dev.	0.018	0.018	0.004	0.042	0.009	0.005	0.005	0.040	0.016	0.007	0.028	0.016	0.016
%Std Dev	0.03878	0.04086	0.10577	0.08907	0.02152	0.0134	0.01262	0.09681	0.03573	0.14923	0.07553	0.0302	0.15864
4 Hour Immersion													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.45	0.46	0.07	0.45	0.40	0.38	0.43	0.46	0.46	0.06	0.31	0.51	0.18
Sample 2	0.46	0.46	0.05	0.44	0.42	0.38	0.41	0.47	0.47	0.04	0.36	0.52	0.19
Sample 3	0.46	0.46	0.05	0.45	0.43	0.41	0.42	0.42	0.44	0.05	0.29	0.51	0.18
Sample 4	0.45	0.45	0.04	0.44	0.41	0.39	0.42	0.44	0.45	0.05	0.32	0.52	0.21
Sample 5	0.47	0.46	0.04	0.46	0.42	0.43	0.43	0.44	0.45	0.04	0.38	0.52	0.16

Determination of Dry Coating													
	A	B	C	D	E	F	G	H	I	J	K	L	M
Average Change	0.46	0.46	0.05	0.45	0.42	0.40	0.42	0.45	0.45	0.05	0.33	0.52	0.18
Std Dev.	0.010	0.007	0.011	0.007	0.010	0.023	0.011	0.022	0.011	0.008	0.038	0.004	0.018
%Std Dev	0.02284	0.0155	0.21288	0.01514	0.02335	0.05755	0.02588	0.04899	0.02444	0.16295	0.11601	0.00711	0.09583
24 Hour Immersion													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.47	0.50	0.07	0.48	0.43	0.42	0.45	0.44	0.47	0.09	0.46	0.51	0.30
Sample 2	0.53	0.50	0.10	0.46	0.43	0.44	0.45	0.44	0.47	0.07	0.46	0.53	0.41
Sample 3	0.50	0.49	0.06	0.48	0.44	0.43	0.46	0.45	0.46	0.09	0.38	0.52	0.35
Sample 4	0.50	0.50	0.06	0.47	0.43	0.43	0.45	0.45	0.47	0.09	0.37	0.54	0.39
Sample 5	0.50	0.53	0.06	0.47	0.44	0.45	0.46	0.46	0.48	0.09	0.38	0.55	0.39
Average Change	0.50	0.50	0.07	0.47	0.43	0.43	0.45	0.45	0.47	0.09	0.41	0.53	0.37
Std Dev.	0.021	0.015	0.016	0.008	0.008	0.012	0.002	0.008	0.009	0.009	0.045	0.014	0.044
%Std Dev	0.04291	0.03002	0.23106	0.01727	0.01853	0.02686	0.00522	0.01866	0.01849	0.10018	0.10931	0.02701	0.11827
48 Hour Immersion													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.50	0.49	0.06	0.45	0.63	0.64	0.67	0.45	0.47	0.10	0.40	0.54	0.36
Sample 2	0.48	0.48	0.07	0.45	0.41	0.42	0.44	0.45	0.48	0.08	0.37	0.53	0.41
Sample 3	0.51	0.51	0.07	0.46	0.42	0.44	0.46	0.45	0.49	0.10	0.45	0.54	0.44
Sample 4	0.53	0.50	0.08	0.48	0.42	0.44	0.45	0.49	0.49	0.13	0.47	0.55	0.30
Sample 5	0.49	0.51	0.10	0.48	0.43	0.44	0.45	0.45	0.50	0.12	0.39	0.54	0.42
Average Change	0.50	0.50	0.08	0.46	0.46	0.48	0.49	0.46	0.48	0.11	0.42	0.54	0.38
Std Dev.	0.019	0.016	0.014	0.016	0.094	0.094	0.098	0.015	0.012	0.018	0.041	0.007	0.054
%Std Dev	0.03849	0.0311	0.18507	0.03356	0.20311	0.19727	0.199	0.03286	0.02434	0.17028	0.09912	0.01268	0.14071
72 Hour Immersion													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.54	0.53	0.14	0.49	0.46	0.45	0.49	0.47	0.53	0.21	0.50	0.56	0.42
Sample 2	0.54	0.53	0.12	0.50	0.43	0.47	0.45	0.48	0.50	0.17	0.42	0.54	0.43
Sample 3	0.47	0.51	0.13	0.45	0.44	0.45	0.46	0.46	0.50	0.29	0.46	0.54	0.42
Sample 4	0.53	0.51	0.14	0.47	0.43	0.44	0.46	0.46	0.22	0.44	0.40	0.53	0.41
Sample 5	0.52	0.51	0.15	0.46	0.43	0.44	0.47	0.46	0.26	0.45	0.41	0.50	0.41
Average Change	0.52	0.52	0.13	0.48	0.44	0.45	0.47	0.47	0.40	0.31	0.44	0.53	0.42
Std Dev.	0.030	0.011	0.012	0.020	0.014	0.012	0.012	0.008	0.145	0.127	0.041	0.020	0.008
%Std Dev	0.05776	0.02052	0.09213	0.04136	0.03278	0.02642	0.0263	0.01813	0.36144	0.40584	0.09274	0.03791	0.01925
German Military Standard Test TL 4020-0015 (BWB) Dynamic Ropes - Method B													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.47	0.47	0.17	0.44	0.41	0.42	0.44	0.43	0.48	0.16	0.45	0.49	0.40
Sample 2	0.47	0.47	0.11	0.44	0.36	0.42	0.44	0.47	0.47	0.15	0.39	0.49	0.39
Sample 3	0.46	0.47	0.10	0.44	0.40	0.41	0.46	0.43	0.47	0.17	0.41	0.46	0.38
Sample 4	0.46	0.47	0.15	0.41	0.40	0.42	0.44	0.43	0.48	-0.11	0.42	0.47	0.39
Sample 5	0.46	0.44	0.12	0.39	0.39	0.39	0.42	0.42	0.46	0.21	0.39	0.46	0.37
Average Change	0.46	0.46	0.13	0.42	0.39	0.41	0.44	0.44	0.47	0.12	0.41	0.47	0.39
Std Dev.	0.008	0.013	0.027	0.022	0.02	0.01	0.011	0.019	0.008	0.131	0.022	0.016	0.011
%Std Dev	0.01631	0.02893	0.21176	0.05097	0.05	0.03	0.02613	0.04463	0.01722	1.10459	0.05372	0.03276	0.02771

Determination of Dry Coating													
	A	B	C	D	E	F	G	H	I	J	K	L	M
1 Hour Immersion	After wash												
Sample Length	200mm - Sealed												
Change													
Sample 1	0.61	0.59	0.04	0.52	0.30	0.16	0.58	0.06	0.53	0.06	0.14	0.54	0.09
Sample 2	0.62	0.61	0.08	0.43	0.37	0.18	0.56	0.09	0.47	0.07	0.13	0.50	0.08
Sample 3	0.62	0.60	0.05	0.52	0.30	0.15	0.54	0.07	0.49	0.06	0.12	0.58	0.06
Sample 4	0.60	0.61	0.08	0.39	0.23	0.17	0.56	0.10	0.50	0.06	0.11	0.51	0.07
Sample 5	0.61	0.62	0.05	0.41	0.43	0.44	0.56	0.12	0.52	0.07	0.18	0.53	0.10
Average Change	0.61	0.61	0.06	0.45	0.33	0.22	0.56	0.09	0.50	0.07	0.14	0.53	0.08
Std Dev.	0.007	0.010	0.018	0.063	0.075	0.122	0.016	0.025	0.025	0.005	0.027	0.029	0.014
%Std Dev	0.01091	0.01653	0.28673	0.13866	0.23023	0.55639	0.02771	0.28307	0.04921	0.08149	0.19533	0.0539	0.17402
Shower Test													
Sample Length	200mm - Sealed												
Change													
Sample 1	0.45	0.48	0.11	0.46	0.41	0.40	0.42	0.42	0.45	0.07	0.21	0.51	0.08
Sample 2	0.43	0.48	0.10	0.45	0.41	0.40	0.42	0.41	0.45	0.08	0.18	0.49	0.08
Sample 3	0.46	0.45	0.12	0.46	0.41	0.41	0.42	0.42	0.46	0.06	0.21	0.49	0.08
Sample 4	0.47	0.46	0.13	0.44	0.40	0.39	0.43	0.41	0.46	0.12	0.20	0.49	0.07
Average Change	0.45	0.47	0.12	0.45	0.41	0.40	0.42	0.42	0.46	0.08	0.20	0.49	0.08
Std Dev.	0.017	0.017	0.011	0.009	0.001	0.009	0.005	0.004	0.005	0.029	0.013	0.010	0.008
%Std Dev	0.03631	0.0359	0.09537	0.02021	0.00285	0.02132	0.01146	0.0086	0.0106	0.34635	0.06333	0.01976	0.099

Wet and Icy Ropes May Be Dangerous!

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Foreword

It is well known that modern mountaineering ropes are made of very thin continuous filaments of polyamide-6, known as nylon. This synthetic fibre is characterised by excellent mechanical properties, such as high breaking strength, large elongation at rupture and good elastic recovery; it is less known that its breaking strength is greatly decreased by water absorption[4]. The dangers that might occur when using wet and frozen ropes in mountaineering can be inferred from the data presented here.

The loss in performance of wet/frozen ropes was first studied at the end of the sixties by a Spanish mountaineer, Prof. José A. Odriozola, and after a couple of years by Fa. Teufelberger and by Pit Schubert, the Chairman of the DAV Safety Working Group. The results they obtained are similar to those presented here. In particular, in Odriozola's two studies on the *static* strength of wet and frozen ropes a reduction of about 30 % in static resistance, as compared to dry ropes, was reported [1] [2]. This prompted the Austrian firm Teufelberger (EDELWEISS ropes) as well as Pit Schubert to investigate to what extent such a reduction might occur for wet ropes in *dynamic* conditions. Tests on wet ropes were carried out on the Dodero machine. Result: ropes that held 2 falls when dry (the minimum imposed by the standards at that time) only held up to 1 fall, or none, when wet [3].

It is astonishing that such a problem hasn't been further studied for thirty years, although the reduction of resistance in wet ropes may be equally and even more important than the loss caused by a long rope wear in mountaineering.

In order to know more about it, a set of tests were made by the author for the Safety Commission (Commissione Materiali e Tecniche, CMT) of the Italian Alpine Club (CAI). They concern new and used ropes, of normal and 'dry' type (i.e. treated with waterproofing substances). The purpose of the tests was to asses the dynamic performance – on the Dodero machine – of a **wet**, **frozen**, and **wet & dried** rope compared to the reference rope.

Description of the tests

The tests were executed on samples of rope of three different makes **A, B, C** (three specimens per sample), with the following characteristics:

A. NEW rope, diameter 10,5 mm, version **normal**

B. NEW rope, diameter 10,5 mm, version **ever dry**

C. USED rope, diameter 10,5 mm, version **normal**

The following samples were subjected to the UIAA test on a Dodero machine:

- **non treated** (reference)
- **wet** (by immersion in water for at least 48 hours, at normal temperature);
- **frozen** (wet as above, then kept for at least 48 hours in a freezer at –30 °C);
- **wet, then dried normally** (wet as above, then laid out in an airy and shady place, as it is convenient to do with your own rope);
- **wet and dried "extra dry"** (wet as above, then centrifuged, then dried at normal temperature in an ventilated room, and finally vacuum-dried in presence of a chemical dehydrator).

A few tests were made on ropes submitted to a shorter soaking, to simulate mountaineering conditions:

- immersion in water for a couple of hours
- brief treatment with splashes of water under a shower

Furthermore, the effect of numerous soaking/drying cycles was studied, drying the ropes under cover (as normally recommended) as well as in direct sunlight.

After each treatment the variations in weight and length of each specimen were checked, in order to investigate possible correlations with the dynamic tests.

Results

The results obtained, listed in TABLE 1, are briefly discussed here.

Wet ropes

The alarming effect of water content on the dynamic performances of a rope has emerged from the tests: the number of falls held on the Dodero is reduced to about 1/3 of the initial value. Such a decrease of performance has been noted on both new and used ropes, and also on both normal and water-proof treated ropes. (Apparently, the waterproofing additive seems to prevent water from sticking to the surface of the sheath, but doesn't stop water from entering the kernel of the rope.) It is interesting that the effect of water is remarkable also in case of brief immersion (2 hours) and even in the case of a simple splash.

Such a behaviour is in accordance with literature [4]: the presence of water in nylon greatly lowers its Tg [a], the Glass Temperature (glass transition temperature of the material). Water acts like a real plasticizer, since it deeply modifies both the mobility of the amorphous part of the macromolecule and the characteristic temperature of me-

chanical relaxation of the material. This means that *"in many respects, the addition of water to nylon is equivalent to raising its temperature by a substantial amount"* (literature). In other words: testing a wet rope on the Dodero at normal temperature is about equivalent to testing the dry rope at 70–80 °C, conditions which cause a loss in performance.

It has also been noted that the impact force at the first fall with the wet rope is significantly larger (5–10 %), as if the rope had become more rigid than the dry one. This could be due to increased fibre-fibre friction as well as to the increased length of the rope. A rope that is already stretched is indeed more resistant to strain, more "rigid". The stretching – average 3–5 % – measured on wet ropes just after removal from water is not negligible compared to the strain that occurs in the Dodero test (30–35 %).

Another unexpected result: the amount of water retained by new ropes is 40–45 % of the weight of the dry rope, independent from the waterproofing treatment (maybe the long soaking time – 48 hours – renders the additive ineffective).

In the case of a used rope, the quantity of water retained is much greater, about 60 %; this is probably due to absorption of water caused by the great quantity of broken filaments existing on the rope surface.

Frozen ropes

A warning must be made here concerning the meaning of the tests: it is not possible to keep the rope icy during the whole test. This is due to the time necessary to mount the rope on the Dodero machine and to the long waiting time required by the standard testing procedure (a succession of falls at intervals of 5 minutes). In addition, the rope is warmed up by the heat due to the energy developed at each fall and to the higher ambient temperature. As a consequence, only during the initial phases of the test were the ropes frozen. Therefore the results must be read critically, trying to extrapolate the results of the ice-effect from our tests.

In spite of these uncertainties, it can be stated that the Dodero tests prove that frozen ropes behave slightly better than wet ropes: there is a smaller reduction ("only" about 50 %) of the dynamic performances, and even a reduction (about –10 %) of the impact force at the first fall.

As a conclusion, we may dare to guess that if we were able to maintain the rope frozen during the whole test the performances of frozen ropes could be even better, maybe almost as good as for dry ropes! At low temperature, in fact, the crystalline structure of the wet rope, in particular the mobility of its amorphous part, would be the same as that of a dry rope at normal temperature.

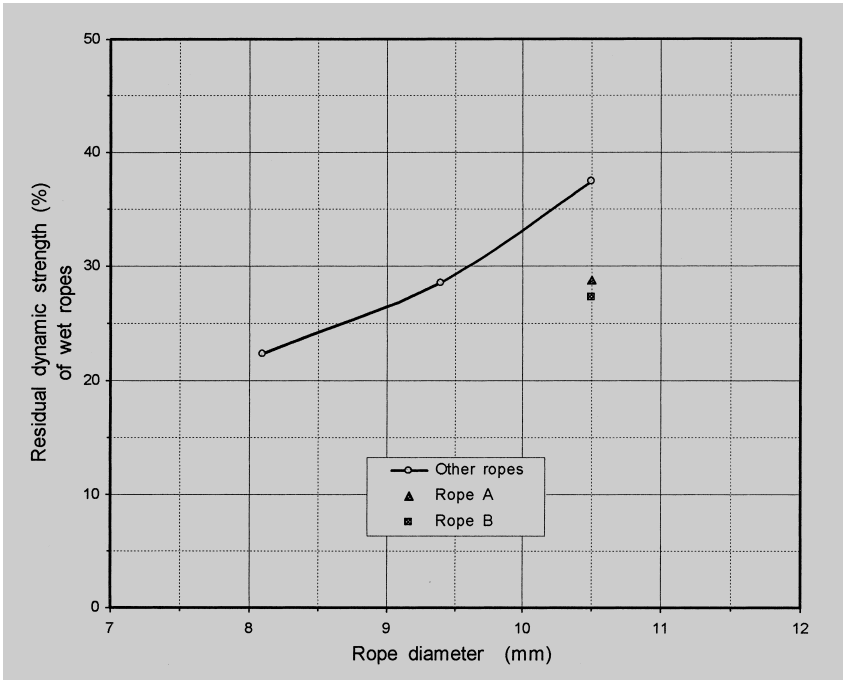

Fig. 1: Correlation between rope diameter and residual dynamic strength of wet ropes

Wet ropes, dried normally

Here is at least one good news for climbers. After soaking and drying, the ropes seem to regain their characteristics, as quoted in literature for nylon fibres. The number of falls on the Dodero machine reaches its original values, while the impact force decreases a little, since the rope is slightly (4 %) shorter.

It is also interesting that the return to the original performance is granted even after various cycles of soaking-drying, as long as the ropes are dried in a cool, airy and shady place. If, however, they are dried in sunlight there is a decrease of performance at the Dodero test, due to the negative effect of the UV radiation [5]. In our case the ropes had been kept in sunlight for 4 weeks, long enough to see these effects.

Wet ropes, dried "extra-dry"

These tests confirm the results reported above. The complete drying of the rope reduces its weight of about 3% compared to the reference case. This thorough drying process leads to an almost complete recovery of the dynamic resistance of the rope – be it new or used, normal or waterproofed – and to a reduction of the impact force at the first fall by about 10–12 % (the rope is about 4–8 % shorter).

Conclusions

The presence of water or ice in climbing ropes produces important modifications in their performance, such as:

1. The dynamic resistance of the ropes (i. e. the number of falls held on the Dodero) decreases enormously – down to 30 % of the initial value – when they are soaked with water, be they new or used, normal or waterproofed.
2. After soaking in water a rope becomes 4–5 % longer, which can be correlated to the 5–10 % increase of the impact force at the first fall on the Dodero machine.
3. The negative effects of water on the dynamic performance of ropes are remarkable even in case of a brief soaking time, even after being splashed under a shower.
4. This behaviour seems to be due to the interaction of water with the crystal structure of the nylon macromolecule (according to literature).
5. Such a behaviour lasts as long as the rope is wet, but after drying – in a cool, airy and shady place, as recommended – the rope recovers almost completely its original dynamic performance, even after various soaking/drying cycles.
6. Depending on the drying grade (normal or thorough) the rope can become shorter by 4 % to 8 %, which seems to be correlated to the decrease by 6–12 % of the impact force at the first fall on the Dodero machine.
7. Even in the case of soaked and frozen ropes the dynamic resistance decreases, but less than in wet ropes.
8. *Relationship between residual strength and rope diameter: see Appendix 1*

In conclusion, a used rope in good conditions, say a rope which can still hold 4–5 falls in the UIAA test on the Dodero machine when dry, might only hold 1 or 2 falls when soaked after a sudden rain fall, as often occurs in the mountains.

This may not be too much of a serious problem when climbing in a *Klettergarten*, where falls are usually less dangerous and it takes little time to pull the rope down and go home. But mountaineers must demand the maximum security from their rope, even when wet, since it might snap on a rough edge during a fall. This risk is lower when the rope is in good condition. The problem can be less critical when climbing a glacier or an ice-fall, because the ropes are frozen, but even in this case the temperature is very important: if it is goes over 0 °C, the rope returns to being wet!

In conclusion, it would be a good idea to change our ropes more often!

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Notes

[a] The Tg, or Glass Temperature, is the glass transition temperature of the material. Polymers, as nylon, are made of macromolecules, where crystal parts (i. e. perfectly orderly chain structures) alternate casually with amorphous parts (i. e. disorderly structures with tangled chains). The temperature at which the mobility of the amorphous part is modified is called glass transition temperature (Tg, Glass Temperature), since the behaviour of the material is similar to that of glass (typical amorphous solid) when it is taken to softening/fusion. The amorphous part of the material goes from a rigid state to a plastic state, with greater mobility; generally all polymers above Tg can be deformed due to their greater plasticity. It has been proved that the presence of water in nylon lowers considerably its glass transition temperature: according to literature, the Tg of dry nylon is 60–80 °C, but for wet nylon it goes down to about 0 °C! This lower Tg in presence of water means that the mechanical properties of the nylon filaments of the rope are strongly modified.

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Appendix 1

Correlation between rope diameter and residual dynamic strength of wet ropes

The correlation between the effects of water absorption and rope diameter deserves further investigation, as suggested by Fig.1. In this Figure the data concerning our ropes A and B are compared with information kindly provided by Michel Beal. His data refer to three different types of rope, but suggest that a curve can be drawn to indicate the improvement in the strength of wet ropes with increasing rope diameter.

The agreement between our data and Beal's can be considered good, particularly considering that Beal's soaking time is much shorter than ours (1 hr instead of 48 hrs).

This additional information is provided here not only to suggest that thicker ropes may be safer in case of bad weather, but also as a warning to those who may be wishing to extend the evaluations discussed in this paper to other types of rope.

Visit the UIAA webpage:
www.uiaa.ch

Table 1

UIAA TEST ON DODERO MACHINE: BEHAVIOUR OF WET, WET & DRIED AND FROZEN ROPES

TREATMENT	TEST	Rope **A** Normal **NEW**	Rope **B** Everdry **NEW**	Rope **C** Normal **USED**
NON TREATED (reference)	**Falls on Dodero No.**	**8**	**11**	**4**
	Impact force daN	**886**	**946**	**950**
WET In water for 48 hours	**Falls on Dodero No.**	**2,3**	**3**	**1,5**
	Impact force daN	**926**	**1022**	**1052**
	Falls variation	–71 %	–73 %	–62 %
	Impact force variation	+5 %	+8 %	+11 %
	Weight variation	+45 %	+42 %	+59 %
	Lenght variation	+4 %	+2 %	+5 %
WET Soaked for 2 hours	**Falls on Dodero No.**		**3**	
	Impact force daN		**984**	
	Falls variation		–73 %	
	Impact force variation		+1 %	
WET With splashes of water	**Falls on Dodero No.**		**5**	
	Impact force daN		**990**	
	Falls variation		–55 %	
	Impact force variation		+2 %	
WET & DRIED IN NORMAL CONDITIONS	**Falls on Dodero No.**	**6**	**9,4**	
	Impact force daN	**867**	**812**	
	Falls variation	–25 %	–15 %	
	Impact force variation	–2 %	–4 %	
	Weight variation	–	–1 %	
	Lenght variation	–	–4 %	
WET & DRIED IN "EXTRA-DRY" CONDITIONS	**Falls on Dodero No.**	**9**	**10**	**3**
	Impact force daN	**785**	**826**	**861**
	Falls variation	+12 %	–9 %	–25 %
	Impact force variation	–11 %	–13 %	–9 %
	Weight variation	–3 %	–3 %	–3 %
	Lenght variation	–7 %	–8 %	–3,5 %
4 CYCLES OF SOAKING AND DRYING UNDER COVER	**Falls on Dodero No.**		**12**	
	Impact force daN		**860**	
	Falls variation		+9 %	
	Impact force variation		–7 %	
4 CYCLES OF SOAKING AND DRYING IN SUNLIGHT	**Falls on Dodero No.**		**8**	
	Impact force daN		**860**	
	Falls variation		–27 %	
	Impact force variation		–9 %	
FROZEN Wet and kept at –30 °C for 48 hours	**Falls on Dodero No.**	**4**	**5**	**3**
	Impact force daN	**805**	**898**	**819**
	Falls variation	–50 %	–64 %	–25 %
	Impact force variation	–9 %	–5 %	–14 %

***Note:** these data are the average over three specimens.*

WATER ABSORPTION, DYNAMIC; TUMBLE JAR METHOD

1. SCOPE

1.1 This method is intended for determining the amount of water absorbed by thread, yarns, tapes, cords, braids, webbings, and narrow cloths when subjected to dynamic conditions.

2. TEST SPECIMEN

2.1 Unless otherwise specified in the procurement document, the specimen shall be 5 pieces of the material 6 to 36 inches (152 to 915 mm) in length, for cord, braid, tape, webbing, and similar materials as specified in Table I, and 1 cabled skein for thread, yarns, light cords, and light braids, prepared as specified in 5.1.

TABLE I

Specimen Weight	Specimen Length
0 thru 4 g/m	36 inches (915 mm)
5 thru 20 g/m	24 inches (610 mm)
21 thru 50 g/m	18 inches (457 mm)
51 thru 100 g/m	12 inches (305 mm)
101 g/m and over	6 inches (152 mm)

3. NUMBER OF DETERMINATIONS

3.1 Unless otherwise specified In the procurement document, two specimens (10 pieces) shall be tested from each sample unit for cords, braids, tapes, webbings, and similar materials, and three specimens shall be tested from each sample unit for thread, light cords, and light braids.

4. APPARATUS

4.2 Tumble jar. A tumble jar (see figure 4500A), cylindrical in shape, with approximate dimensions of 12 inches (305 mm) in height and 6 inches (152 mm) in diameter or between opposite flat faces, and with a capacity of approximately 6 L. The jar shall be of glass, corrosion-resistant metal, or chemical stoneware. The jar shall be mounted in a vertical position, in such a manner that it can be rotated around the horizontal axis passing through the center of the jar. Means shall be provided for rotating the jar around the axis at a rate of 55 ± 2 revolutions per minute. The jar shall be clean and thoroughly rinsed so that it is free from soap, detergent, and wetting agents (see 7.1).

4.2 Wringer. A wringer (see figure 4500B), of the household type, equipped with smooth rubber squeeze rolls 2-1/8 to 2-1/2 inches (54 to 64 mm) in diameter and not less than 11 inches (279 mm) or more than 16 inches (406 mm) in length. The rubber rolls shall have a Shore durometer hardness of 70 to 80 (A scale). The load exerted on the specimen shall be applied uniformly by means of a dead weight attached to the top roller. The total load of the roller, means of attaching the weight, and the weight itself shall be 60 pounds (27 kg). The rolls shall be power driven at such a speed that the specimen shall pass through the rolls at a rate of 1 inch (25 mm) per second.

4.3 Balance. Laboratory balance accurate to 0.01 g.

4.4 Blotting paper. The blotting paper dimensions shall be approximately 1 inch greater than the length and width of the specimens (see 7.3).

4.5 Yarn reel. A 54-inch (1.37 m) periphery skein reel or other suitable device for preparing a skein.

4.6 Twist tester. A twist tester or other suitable device for twisting skeins.

4.7 Container. Tared glass or plastic containers.

5. PROCEDURE

5.1 Preparation of thread, yarns, light cord and light braid specimens. The test specimens shall consist of 5.0 ± 1.0 g skeins made on a 54-inch (1.37 m) periphery skein reel. The skein shall be folded flat, then twisted around its long axis for a total of 25 turns using a twist tester (see figure 4500C). The twist must be inserted In the skein in the same direction as the final twist of the specimen. The two ends shall be brought together and the folded skein allowed to back twist on itself. The ends shall be tied off to prevent untwisting (see figure 4500D).

5.2 Time of rotation. Unless otherwise specified in the procurement document, the time of rotation of the jar (test time) shall be a minimum of 10 minutes for threads, yarns, light cords and light braids; and a minimum of 20 minutes for webbings, tapes, heavy cords and braids, and narrow cloths.

5.3 Weight of original specimen. The specimen, 5 pieces of cord, braid, tapes, webbing, or narrow cloths, or 1 cable skein for lighter materials, shall be conditioned and weighed to the nearest 0.1 g. This is the “Weight of the original conditioned specimen”, and in the calculation of results is designated as 0 l Each individual piece of the specimen for cord, braids, tapes, and webbings shall be marked to maintain its identity.

One L of distilled water for threads, yarns, light cords and light braids, and 2 L of water for webbings, tapes, or narrow cloths-at a temperature of 80° ± 2°F (27°C ± 1°C) shall be placed in the tumble jar (see 4.1) and the specimen added.

5.3.1 Cords, braids, webbings, tapes, or narrow cloths. Two specimens (10 pieces) may be tested at the same time, provided each specimen is taken from a different sample unit. If less than 2 specimens are tested, a clean specimen of comparable weight, finish, size, and type of cloth shall be run as ballast with the specimen undergoing test. Care shall be taken that the material in the jar during any run shall be the equivalent weight of the 2 specimens.

5.3.1.1 The jar and contents shall be rotated at the rate of 55 ± 2 revolutions per minute for the time specified.

5.3.1.2 At the end of the required running time, one piece of the specimen shall be run through the wringer smoothly with the lengthwise direction of the specimen perpendicular to the length of the rollers.

5.3.1.3 The same piece of the specimen shall immediately be placed smoothly between 2 sheets of blotting paper. The specimen and blotters shall be passed through the rollers of the wringer by the procedure described in 5.3.1.2.

5.3.1.4 The piece of material shall be left between the 2 blotters until all 5 pieces (between sheets of blotting paper) have been passed between the rollers as described in 5.3.1.2 and 5.3.1.3.

5.3.1.5 Final weight of specimen. The 5 pieces constituting the specimen shall then be removed from the blotting paper and weighed immediately in a tared closed container to the nearest 0.1 g. This is the “Final weight of the specimen”, and in the calculation of results is designated as “F”.

5.3.2 Thread yarns, light cords and light braids. No more than 1 cabled skein shall be tested In the jar at one time.

5.3.2.1 The jar and contents shall be rotated at the speed of 55 ± 2 revolutions per minute for the time specified.

5.3.2.2 At the end of the required running time, the specimen shall be run through the wringer smoothly with the lengthwise direction of the specimen perpendicular to the length of the rollers.

5.3.2.3 The same specimen shall immediately be placed smoothly between 2 sheets of blotting paper. The specimen and blotters shall be passed through the rollers of the wringer by the procedure described in 5.3.2.2.

5.3.2.4 Final weight of specimen. The specimen shall then be removed from the blotting paper and weighed immediately in a tared closed container to the nearest 0.1 g. This is the "Final weight of the specimen", and in the calculation of results shall be designated as "F".

5.4 Care shall be taken at all times to keep evaporation of moisture from the specimen to a minimum.

5.5 Calculation of results. The dynamic absorption shall be calculated as follows:

$$\text{Dynamic absorption, percent} = \frac{F - O}{O} \times 100$$

Where: O = Original weight of the specimen.

F = Final weight of the specimen.

6. REPORT

6.1 The dynamic absorption of the sample unit shall be the average of the results obtained from the specimens tested, and shall be reported to the nearest 0.1 percent.

6.2 Each individual value used to calculate the average shall also be reported.

7. NOTES

7.1 A tumble jar suitable for conducting this test may be purchased from Atlas Electric Devices Co., 4114 N. Ravenwood Ave., Chicago 13, Illinois, and Illinois and Mico Instrument Co., 80 Trowbridge St., Cambridge, MA 02138.

7.2 If the material for test is subject to excessive raveling, a drop of liquid latex or rubber cement should be spread on the yarns at each corner to prevent raveling. Care should be exercised in the selection of the latex or rubber cement to insure impurities are not present which would affect results.

7.3 The blotting paper is available from: James River Paper Company, P.O. Box 2218, Richmond, VA 23217.

DYNAMIC ABSORPTION TEST

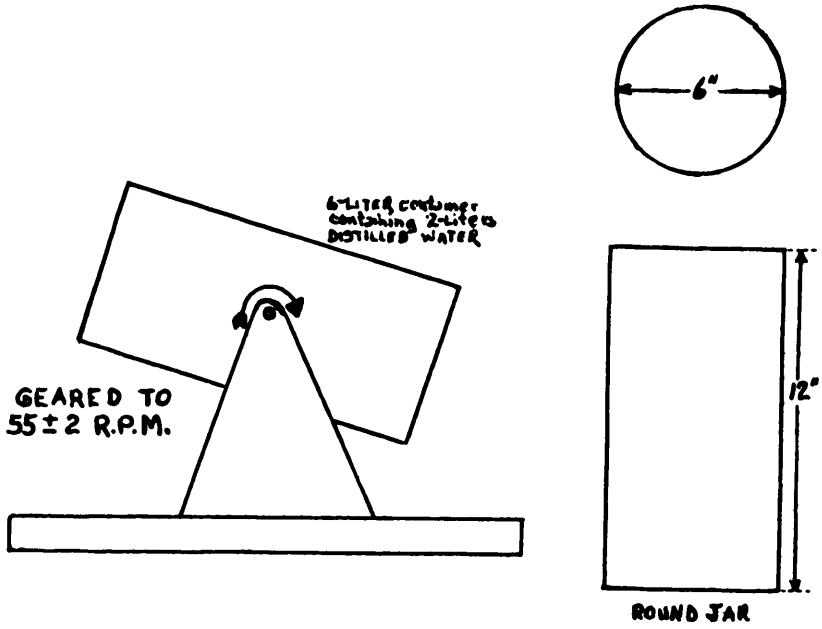

FIGURE 4500A - TUMBLE JAR

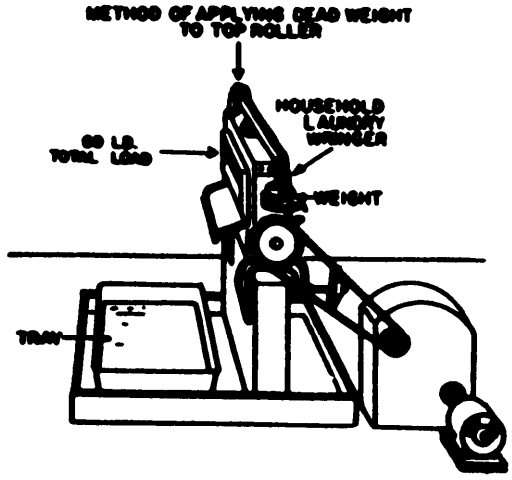

FIGURE 4500B- WRINGER

WATER ABSORPTION; CORDAGE

1. SCOPE

1.1 This method is intended for determining the water absorption of cordage.

2. TEST SPECIMEN

2.1 The test specimen shall be a single length 15 inches (381 mm) long cut from a sample unit.

3. NUMBER OF DETERMINATIONS

3.1 Unless otherwise specified in the procurement document, five specimens shall be tested from each sample unit.

4. APPARATUS

4.1 Tension apparatus. Any suitable device may be used for applying the required load.

4.2 Container. A suitable container In which the test specimen shall be immersed as required.

4.3 Wire rack for drying the specimen during testing.

4.4 Marking medium. Pen marker containing water-insoluble ink.

5. PROCEDURE

5.1 Unless otherwise specified in the procurement document, the specimens shall be brought to equilibrium under Standard Atmospheric Conditions in accordance with Section 4 of this Standard.

5.2 Tension a suitable length of the cordage with a weight equal to 1 percent of the minimum breaking strength specified for the cordage tested, and mark off the required 15 inch (381 mm) specimen length.

5.3 The load is released on the sample unit and the specimen cut out at the marks. A mark is placed 3 inches (76 mm) from each end of the specimen using water-insoluble ink or other suitable marking material.

5.4 The specimen shall be weighed to the nearest 0.1 g.

5.5 The specimen shall be looped, and the loop immersed in a container of distilled water at room temperature until the water surface is level with, but not below or over the marks, so that the cut ends are out of the water.

5.6 The specimen shall be allowed to steep for 24 hours.

5.7 The specimen shall be removed and cut at the mark, thus removing the cut ends that were not immersed in the water.

5.8 The specimen shall be placed in a draft free area of the conditioned room on a wire rack, care being exercised to prevent shaking or squeezing of the specimen to remove the excess water. The specimen shall be laid horizontally and not touched again until the expiration of the required time for draining. The specimen shall be allowed to drain 1-1/2 hours.

5.9 At the end of the 1-1/2 hour period, the sample shall again be weighed and the amount of water absorption recorded.

5.10 Calculations.

$$\text{Water absorbed, percent} = \frac{(\text{Weight (g) of steeped sample with ends cut}) - 9/15 \text{ of original sample weight (g)}}{9/15 \text{ of original sample weight (g)}} \times 100$$

6. REPORT

6.1 The amount of water absorbed shall be the average of the specimens tested, and shall be reported to the nearest 1.0 percent.

6.2 Each individual value used to calculate the average shall also be reported.

47 Wasseraufnahme (Beregnungstest)

1 Geltungsbereich

Alle Super-Dry ausgerüsteten Bergseile, Statikseile, Reepschnüre etc.

2 Geräte und Vorrichtungen

01 Holzrahmen mit Netz bespannt, ca. 50 x 50 cm

02 DIN-Brause, 18 l/min, ca. 150 cm über dem Netzmittelpunkt

03 Waage Mettler P-1200 (Prüfmittel Nr. 492)

3 Probe

01 Die Proben werden vor der Prüfung gemäss AA 06.05.40 klimatisiert

02 3 Stk. à ca. 300 mm, Enden abgeschmolzen, einzeln gekennzeichnet.

4 Durchführung

01 Es wird das Trockengewicht bestimmt

02 Die Prüfmuster werden auf das Netz gelegt und 2.5 min beregnet.

03 Nach der Beregnung wird das anhaftende Oberflächenwasser abgeschüttelt.

04 Es wird sofort das Nassgewicht bestimmt

5 Berechnungen

Die Wasseraufnahme wird als Prozentsatz des Trockengewichts berechnet. Es ist der Durchschnitt der drei Messungen gerundet auf eine 0.1 % anzugeben.

6 Sollwerte

Es bestehen keine Vorgaben der Norm.
Für Bergseile und Reepschnüre wurde ein Richtwert von <= 15 % festgelegt.

2.3 Veredlung

2.3.1 Färben

2.3.1.1 Mantelfarben

Versorgungsnummer 4020-12-341-1276 : RAL 9011 graphitschwarz als Anhalt
Versorgungsnummer 4020-12-341-1277 : RAL 6003 olivgrün als Anhalt

2.3.1.2 Farbechtheiten

	Änderung der Farbe	Anbluten auf Polyamid	Anbluten auf Wolle
Lichtechtheit	4	-	-
Wasserechtheit, schwere Beanspruchung	3	3	3
Waschechtheit 60 °C, Test 3	3	3	3

Die vorstehenden Echtheitsnoten sind Mindestwerte und gelten für die Seilmantelgarne und Kennfäden.

2.3.2 Ausrüsten

2.3.2.1 Imprägnierung

Rohfassung

Vollimprägnierung für Wasser- und Scheuerschutz.
Es darf keine Zerstörung des molekularen Aufbaus des Rohmaterials eintreten.
Die Imprägnierung hat eine Transparenz aufzuweisen, die zu keiner farblichen und qualitativen Veränderung in Verbindung mit den Mindestwerten der Farbechtheiten führt.

Wasseraufnahme: im Anlieferungszustand: $\leq$ 15 %
nach Wäsche : $\leq$ 50 %
Prüfung nach DIN EN 26330
Waschmaschine Typ A1
Verfahren 3A
Trocknungsverfahren C

2.3.2.2 Scheuerfestigkeit

Nach Anhang B 1
Bis zur Manteldurchscheuerung: mindestens 4000 Scheuerzyklen, gemessen im Einzelstrang

oder
nach Anhang B 2 (PFL-System)
Seil-Höchstzugkraft: $\geq$ 1 000 daN nach 10 000 Scheuerzyklen, gemessen im Einzelstrang, Prüfung analog DIN EN 564, Abschnitt „Bestimmung der Bruchkraft"

2.3.3 Säure- und Alkaligehalt der fertig ausgerüsteten Bergseile

pH-Wert des wässrigen Auszuges der Probe nicht unter pH 4,8 und nicht über pH 7,5. Prüfung nach DIN 54276.

2.3.4 Kennzeichnung der Seile

2.3.4.1 Jedes gebrauchsfertig abgelängte Halbseil ist nach DIN EN 892-1 zu kennzeichnen.
Zusätzlicher Aufdruck der Seillänge: 50 m.

2.3.4.2 CE-Kennzeichnung laut PSA.

2.3.4.3 Kennfäden

Hersteller: Durch Kennfäden zwischen den Kernelementen
Werkstoff Polyamid: RAL 6032 Signalgrün als Anhalt, durch Kennfäden zwischen den Kernelementen

gungen eingehalten wurden.

Nach DIN EN 892 und abweichend davon

Fallversuch im Einzelstrang nach Anhang A.1
Probenanzahl: mindestens 3
Fallversuch im Doppelstrang nach Anhang A.2 und Anhang A.3.
Nach Anhang A.3 ruhen die Seile auf der scharfen Kante, statisch belastet mit einem Fangteller der Masse (5,0 ± 0,1) kg.
Die fallende Masse (80 kg) fällt auf den Fangteller.
Alle anderen Testkriterien sind gegenüber dem Anhang A.2 nicht geändert.
Probenanzahl: mindestens 5.
Hält nur eine Probe den Sturz nicht aus, gilt die Prüfung als nicht bestanden.

3.1.2 Ablieferungsprüfung

Nachstehend aufgeführte Prüfungen sind vom Auftragnehmer durchzuführen. Die Ergebnisse sind zu dokumentieren.

3.1.2.1 Scheuerfestigkeit

Prüfbedingungen nach DIN EN 892 und Abschnitt 2.3.2.2

- Scheuerversuch nach Anhang B.1
  Bei einer konstanten Belastung läuft das Prüfseil sich drehend wechselweise vorwärts und rückwärts über eine Granit-Scheuerkante.
  Das Prüfseil läuft bis zur Durchscheuerung auf der gleichen Scheuerstelle.

oder

- nach Anhang B.2 (PFL-System).
  Bei einer konstanten Belastung läuft das Prüfseil wechselweise vorwärts und rückwärts unter einem maximalen Umschlingungswinkel von 39 Grad und minimalen Umschlingungswinkel von 12 Grad über eine Prüfkante mit Kantenradius 0,5 mm.
  Die Prüfkante besteht aus Hartmetall der Type 'Krupp-Widia THM'.

3.1.2.2 Prüfung der Wasseraufnahme durch Methode A oder Methode B

Methode A: dynamische Wasseraufnahme.

Prüfmittel: Zylindrische Trommel 305 mm x 150 mm (ca. 6 l) aus Glas oder korrosionsbeständigem Material.
Von dem Seilmaterial werden mindestens 10 Proben mit einer Länge von 300 mm abgeschnitten. Die Seilenden sind vollständig zu verschweißen, damit während der Prüfung an den Stirnseiten der Proben kein Wasser eindringt.

Die an das Normalklima nach DIN EN 20139-20/65 angeglichenen Proben werden auf 0,01 g gewogen (= Gewicht M_K) und anschließend in der Trommel mit 2 l Wasser (27 ± 2) °C, 0,72 mmol/l CaO (4 °dH) 20 min mit einer Drehzahl n = (55 ± 2) min^{-1} ständig gedreht.

Nach Ablauf der 20 min werden die Seilstücke aus der Trommel entnommen und binnen 2 min zur Entfernung des überschüssigen Wassers geschleudert.

Schleudereinrichtung:
- Anlehnung an DIN EN 29865
- Scheibendurchmesser: 300 mm
- Umdrehungszahl: n= 700 min^{-1}
- Schleuderdauer: 30 s.

Die Umdrehungszahl ist nach mindestens 5 s zu erreichen. Es sind mindestens 2 Seilstücke pro Vorgang in geeigneter Weise, jedoch mindestens in der Mitte des Tellers, zu befestigen (z.B. mit Stahlnadeln oder Kabelbindern).

Die Proben müssen nach dem Schleudervorgang auf 0,01 g zurückgewogen werden (= Gewicht M_n)

oder

Methode B: Schwimmtest.

Von dem Seilmaterial werden 10 Proben mit einer Länge von 200 mm abgeschnitten. Die Seilenden sind vollständig zu verschweißen, damit während der Schwimmzeit an den Stirnseiten der Probe kein Wasser eindringt. An den beiden Seilenden wird ein dünner Synthetikfaden eingezogen und zu einer Schlaufe verknotet. Die an das Normalklima DIN EN 20139-20/65 angeglichenen Proben werden auf 0,01 g gewogen (= Gewicht M_k) und anschließend für 72 h in einen Behälter mit Wasser (20 ± 2) °C, 0,72 mmol/l CaO(4 °dH) gegeben.

Nach Ablauf der Prüfung nach Methode A oder Methode B erfolgt eine Bestimmung der Wasseraufnahme.
Die Seilstücke werden hierzu senkrecht an einem Probenständer aufgehängt. In die untere Schlaufe des Seilabschnittes wird vorsichtig ein 500 g Gewicht eingehängt. Unter der Gewichtsbelastung tritt über die gesamte Probenlänge eine Parallelisierung von Seilmantel und Seilkern ein, so daß überschüssiges Wasser nach außen abgepreßt wird. Sollten nach einer Abtropfzeit von 180 s am unteren Seilende noch Wassertropfen anhaften, so werden diese vorsichtig mit einem Vliespapier entfernt. Die Probe wird auf 0,01 g zurückgewogen (= Gewicht M_n). Alle Meßproben müssen im geschlossenen Wägeglas gewogen werden.

Die Berechnung der Wasseraufnahme (W_A) nach Methode A oder Methode B erfolgt nach folgender Formel:

$$W_A = \frac{M_n - M_k}{M_k} \times 100\ (\%)$$

3.1.2.3 Prüfung der Seil-Lieferlänge

Das Seil muß vor der Prüfung mindestens 72 h im Normalklima gelagert werden. Die Prüfung der Seil-Lieferlänge erfolgt auf einer ebenen glatten Unterlage, so daß das Be- und Entlasten des Seiles nur unwesentlich beeinträchtigt wird. Das Seil wird in der Mitte an einem feststehenden Haken gehalten und jedes Seilende langsam ansteigend bis zum 100fachen m-Gewicht belastet und nach etwa 30 s wieder entlastet. Die Länge wird erst geprüft, wenn keine Längenänderung mehr erkennbar ist (nach ca. 2 min.).

3.1.3 Stichprobenprüfung

Als Kriterium für die Freigabe der Lieferung aufgrund von Stichprobenprüfungen gilt für diese Prüfungen:

Prüfung auf fehlerhafte Einheiten nach einem Einfach-Stichprobenplan für normale Prüfung - Prüfniveau II - mit AQL 2,5 nach DIN ISO 2859-1 unter Beachtung von VG 95082-3.

Ein zurückgewiesenes Los darf - sortiert oder nachgearbeitet und unter der Maßgabe, daß der Auftragnehmer die getroffenen Maßnahmen darlegt - einmal wiedervorgestellt werden. Das zur Wiederholungsprüfung vorgestellte Los wird den gleichen Prüfungen wie bei der Erstvorstellung unterworfen, jedoch wird die Prüfung der beanstandeten Merkmale und der Merkmale, die durch die Behebung der Beanstandung beeinflußt werden können, nach einem Stichprobenplan durchgeführt, dessen AQL zwei Stufen kleiner ist als die für die erste Prüfung vereinbarte AQL. Ist eine Beseitigung der Fehler nicht möglich oder nicht zugelassen, bzw. erfüllt das zur Wiederholungsprüfung vorgestellte Los nicht die Annahmekriterien, so ist das Los zu verwerfen.

3.2 Gütesicherung

Der Auftragnehmer muß ein Gütesicherungssystem nach "AQAP-130, NATO-Qualitätssicherungsforderungen für Qualitätsprüfung" unterhalten, bzw. das Qualitätssicherungssystem muß nach DIN EN ISO 9001 zertifiziert sein.