EXOVA REPORT

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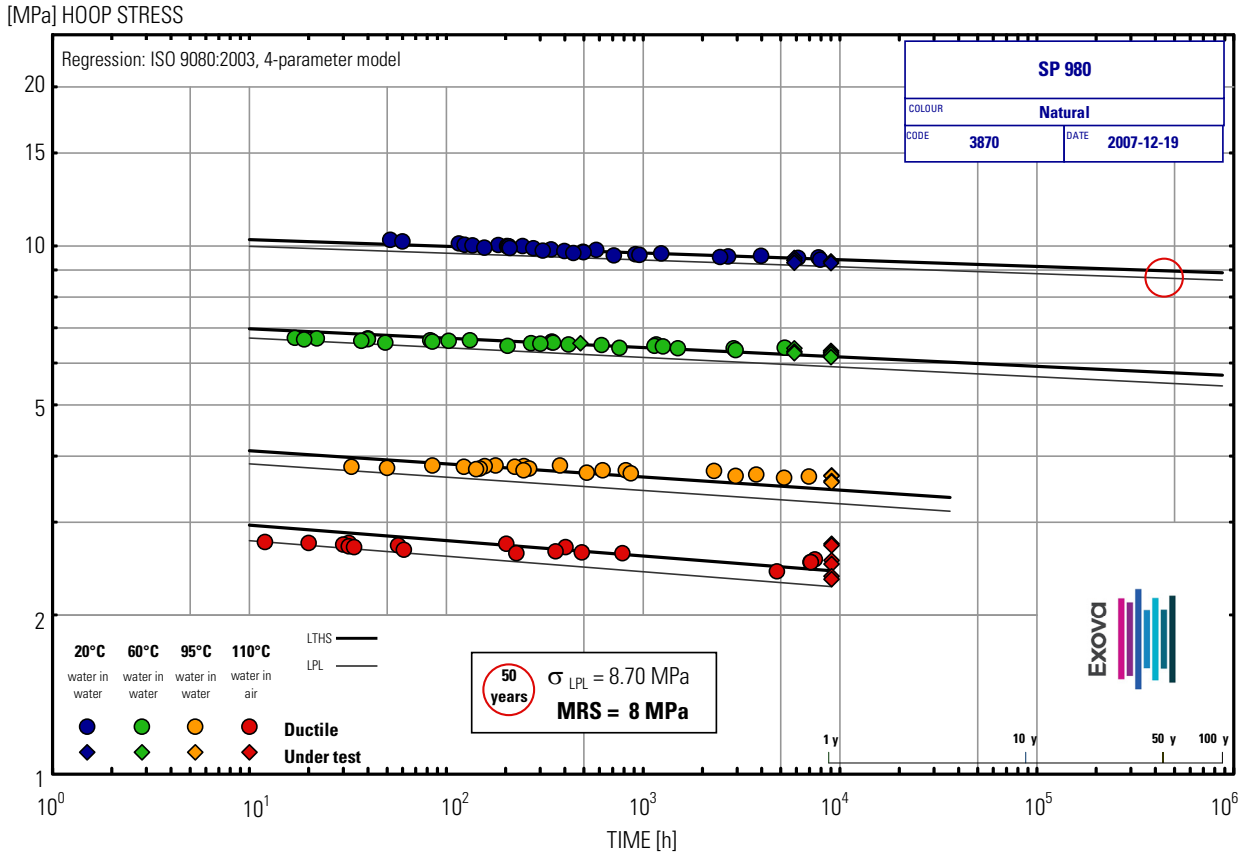
DETERMINATION OF THE LONG-TERM HYDROSTATIC STRENGTH

ISO 9080:2003-evaluation of the PE-RT pipe grade SP 980 Natural from LG Chem, Ltd.

Mattias SVEDBERG



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DETERMINATION OF THE LONG-TERM HYDROSTATIC STRENGTH ISO 9080:2003- evaluation of the PE-RT pipe grade SP 980 Natural from LG Chem, Ltd.

ABSTRACT

The aim of this project was to determine the long term hydrostatic strength of the PE pipe grade SP 980 Natural according to ISO 9080 and then MRS-classify it according to ISO 12162.

The ISO 9080-evaluation of the pipe grade gives the following strength values at 20°C and 50 years;

T	Time	σ_{LPL}	σ_{LTHS}
20°C	50 yrs	8.70 MPa	8.98 MPa

By its LPL value of 8.70 MPa at 20°C and 50 years the PE pipe grade PTT-8100M SEKISUI from Sekisui has a minimum required strength (MRS) of 8 MPa and is thereby designated PE-RT 80 according to ISO 12162:1995.

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1 EVALUATED PIPE GRADE

A short presentation of the evaluated pipe grade is presented below and detailed information is given in Appendix B.

Table 1 *Evaluated pipe grade*

Trade name	SP 980
Pipe colour	Natural
Pipe material	PE-RT
Nominal pipe dimension	32 x 3 mm
EXOVA internal code	3870

2 EXPERIMENTAL PROCEDURE

The hydrostatic pressure testing is performed at Exova according to ISO 1167:2006. The pressure testing at 20, 60 and 95°C is performed using deionised water on the inside and on the outside of the pipe specimens. At 110°C air is used on the outside. The accuracy for temperature[1] and pressure[1] is better than ±1°C and +2/-1% respectively. The measurements of the wall thickness[1] are accurate within ±0.01 mm and the diameter[1] within ±0.1 mm.

3 RESULTS FROM THE HYDROSTATIC PRESSURE TESTING

The results obtained from the hydrostatic pressure testing are presented in Appendix B and shown in Appendix C. Table 2 gives a summary of the observations.

Table 2 *Summary of the results from the hydrostatic pressure testing*

T	Total no of samples [1]	Failed samples [1]	Ongoing samples [1]	Stopped samples [1]	Longest failure time [h]	Longest test time [h]
20°C	49	34	15	0	7 941	9 000
60°C	54	33	21	0	5 233	9 000
95°C	55	37	18	0	6 957	9 048
110°C	54	29	25	0	7 451	9 048

[1] The expanded uncertainty of measurement has been calculated as the standard uncertainty of measurement multiplied by the coverage factor K=2, which for a normal distribution corresponds to a coverage probability of approximately 95%. The standard uncertainty of measurement has been determined in accordance with EA Publication EA-4/16:2003 and is documented at EXOVA.

4 ISO 9080-EVALUATION

The ISO 9080-evaluation consists of multiple linear regression analysis (MLR) on the stress rupture data obtained at the different test temperatures. The MLR is performed using the software Becetel SEM v1.17.

The ISO 9080 also includes extrapolation factors that determine to what times we can extrapolate at each temperature. The maximum extrapolation time is 100 years.

4.1 General model for the regression analysis according to ISO 9080

The general 4-parameter model used in ISO 9080 is the following:

$$Log(t) = C_1 + C_2 \cdot \frac{1}{T} + C_3 \cdot Log(\sigma) + C_4 \cdot \frac{Log(\sigma)}{T} + e$$

where

C_1 *to* C_4	*parameters used in this model*	
t	*time to failure*	*[h]*
T	*Temperature*	*[K]*
σ	*Hoop stress*	*[MPa]*
e	*error variable*	*Laplace-Gaussian distribution, with zero mean and constant variance (the errors are assumed to be independent)*

The 4-parameter model shall be reduced to a 3-parameter model if the probability level of C_3 is greater than 0.05. i.e. $C_3 = 0$.

5 RESULTS FROM THE ISO 9080 EVALUATION

The diagram in Appendix C.2 shows the observations and lines for σ_{LPL} and σ_{LTHS} for the selected analysis.

5.1 Comments on selecting the data set for ISO 9080

- Data points equal to and below 40 h at 20°C was excluded from the analysis in accordance with paragraph 4.2.3 in the ISO 9080 document.
- A knee was detected at 60°C after 4 752 h and 6.37 MPa by the software. However, as the knee was caused by ongoing pipes and no knee was detected only using failures and finally only ductile failures have occurred, the failure mode was manually changed from 'B' to 'A' for all data points equal to and below 6.37 MPa at 60°C

5.2 Distribution of stress rupture data

Table 3 presents the distribution of observations for the data set that was used in the ISO 9080-evaluation.

Table 3 *Distribution of the stress rupture data included in the ISO 9080 evaluation*

T	Samples				Distribution		Pressure levels	Excluded samples[3)]
	Total	Failed	Ongoing	Stopped	>7 000 h	>9 000 h		
20°C	30	5	35	0	4	2	7	0
60°C	27	8	35	0	4	4	5	0
95°C	31	4	35	0	4	4	5	0
110°C	22	8	30	0	11	6	5	0
Requirement[1)]	*30*	-	-	-	*4*	*1*	*5[2)]*	-

1) Indicate the required number of observations according to ISO 9080.

2) Indicate the required number of pressure levels at which at least two observations have been recorded according to paragraph 4.2.1 in ISO 9080.

3) Number of pipes included in the distribution analysis, but not in the regression analysis.

5.3 Regression analysis model

Different analyses were performed adding pipes that still were in progress and using the 3 or 4-parameter models. The 4-parameter model was finally chosen, as the probability level for C_3 was ≤0.05. Table 4 presents the regression coefficients and the standard error values for the selected analysis, i.e. only valid for the pipes with the Exova code 3870.

Table 4 *Regression coefficients for the selected model*

FIRST BRANCH	C_1	C_2	C_3	C_4
Value	-190.678	79 628.015	111.423	-55 818.413
Standard error	12.572	51 37.324	7.884	3 752.972

5.4 Extrapolation time limits

Table 5 below shows the different extrapolation time limits for the different test temperatures.

Table 5 *Extrapolation time limits*

T_t [1]	t_{max} [2]	Extrapolation time limits, t_e [3], at different service temperatures, T_s			
		20°C	**60°C**	**95°C**	**110°C**
20°C	7 894 h	0.90 yrs	-	-	-
60°C	8 259 h	47.1 yrs	0.94 yrs	-	-
95°C	8 585 h	98.0 yrs	29.4 yrs	0.98	-
110°C	9 048 h	100 yrs [4]	100 yrs	4.13 yrs	1.03 yrs

1) *T_t is the test temperature*

2) *The maximum test time. t_{max} is the logarithmic average of the 5 longest observations.*

3) *The extrapolation time limit, t_e, is calculated from the relation: $t_e = t_{max} \cdot K_e$, where K_e is the extrapolation time factor that is a function of the difference in service temperature T_s and the test temperature, T_t. Underlined values indicate the longest extrapolation time limit obtained at a specific service temperature*

4) *The maximum extrapolation time is 100 yrs*

5.5 Extrapolated strength values

The selected model gives the following extrapolated strength values corresponding to 50 years at 20°C and to the extrapolation time limits at the test temperatures.

Table 6 *Extrapolated strength values*

Time	σ_{LTHS} [MPa]				σ_{LPL} [MPa]			
[h]	**20°C**	**60°C**	**95°C**	**110°C**	**20°C**	**60°C**	**95°C**	**110°C**
	10.589	7.265	4.337	3.166	10.278	6.970	4.094	2.957
10	10.285	6.973	4.096	2.960	9.989	6.695	3.870	2.768
100	9.990	6.693	3.868	2.768	9.704	6.426	3.655	2.589
1 000	9.703	6.424	3.653	2.588	9.423	6.164	3.449	2.418
10 000	9.424	6.166	3.449	-	9.145	5.909	3.252	-
100 000	9.153	5.918	-	-	8.872	5.661	-	-
50 yrs	8.983	5.764	-	-	8.699	5.506	-	-
100 yrs (t_e 20°C)	8.905	5.693	-	-	8.618	5.434	-	-
100 yrs (t_e 60°C)	8.905	5.693	-	-	8.618	5.434	-	-
4.13 yrs (t_e 95°C)	9.272	6.026	3.341	-	8.992	5.769	3.146	-
1.03 yrs (t_e 110°C)	9.436	6.177	3.458	2.427	9.157	5.920	3.260	2.264

5.6 Classification according to ISO 12162

By its LPL value of 8.70 MPa at 20°C and 50 years the PE-RT pipe grade SP 980 Natural has a minimum required strength (MRS) of 8 MPa and is thereby designated PE-RT 80 according to ISO 12162:1995.

6 ADDITIONAL COMMENTS

No unusual behaviour was observed during the hydrostatic pressure testing.

REFERRED DOCUMENTS

- ISO 1167:2006
  Thermoplastics pipes, fittings and assemblies for the conveyance of fluids – Determination of the resistance to internal pressure
- ISO 9080:2003
  Plastics piping and ducting systems –Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation
- ISO 12162:1995
  Thermoplastics materials for pipes and fittings for pressure applications — Classification and designation – Overall service (design) coefficient
- ISO/IEC 17025:2005
  General requirements for the competence of testing and calibration laboratories
- EA-4/16:2003
  EA guidelines on the expression of uncertainty in quantitative testing
- EXOVA P-07/159
  DETERMINATION OF THE LONG-TERM HYDROSTATIC STRENGTH ISO 9080:2003-evaluation of the PE-RT pipe grade SP 980 Natural from LG Chem, Ltd testing

CLIENT INFO

Client	LG Chem, Ltd.
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MATERIAL INFO

Exova code	3870
Trade name	SP 980
Material	PE-RT
Colour	Natural
Nominal dimension	32 x 3 mm
Arrival date at Exova	2006-12-01
Amount	100 x 1.0 m
Consignor	LG Chem, Ltd.
Condition of material at arrival	No visual defects
Marking	n/a
Resin producer	LG Chem, Ltd.
Resin production site	-
Resin production batch no	-
Resin production date	-
Pipe producer	-
Pipe production site	-
Pipe production batch no	-
Pipe production date	-
Method of manufacturing	Extrusion

TEST INFO

Test laboratory	Exova Plastic Pipes, Swedac accreditation no. 0067
Responsible	Niklas Eriksson
Test method	ISO 1167:2006
Length (total/free)	350/310 mm
Fittings	Brass fittings and type A, unless remarked
Internal medium	Water
External medium	Water (Air at 110°C)
Conditioning time	3 h
Situation on	2007-12-19

TABLE REMARKS

Code	Exova internal code
T	Test temperature
Start date	Date when the pipe sample was started
Reg date	Date when the sample was stopped or registered as failure.
$\mathbf{e_{min}}$	Minimum wall thickness
$\mathbf{d_{em}}$	Mean outside diameter
p	Internal pressure
σ	Circumferential stress (hoop stress)
->	The pipe is under test

PIPE REMARKS

1 The sample is discarded as the failure time is less than 1 000 h and the test temperaure equal to or below 40˚C

2 The pipe is fitted with PVDF-fittings

3 The pipe was stopped due to a technical error

The pipe is included in the ISO 9080 evaluation

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-1	20	061204	061205	31.98	3.05	22.65	10.74	16	Ductile		
3870-2	20	061204	061206	32.00	3.05	22.26	10.56	28	Ductile		
3870-3	20	061204	061206	31.95	3.05	22.26	10.55	36	Ductile		
3870-4	20	061204	061206	31.96	3.04	21.87	10.40	40	Ductile		
3870-5	20	061204	061207	31.98	3.04	21.58	10.27	52	Ductile		
3870-6	20	061204	061207	32.00	3.06	21.58	10.20	60	Ductile		
3870-7	20	061204	061211	32.00	3.06	21.38	10.11	116	Ductile		
3870-8	20	061204	061211	32.00	3.00	20.79	10.05	124	Ductile		
3870-9	20	061204	061212	31.95	3.05	21.18	10.04	184	Ductile		
3870-10	20	061204	061211	32.00	3.06	21.18	10.02	136	Ductile		
3870-11	20	061204	061215	31.95	3.06	21.18	10.00	244	Ductile		
3870-12	20	061204	061213	31.95	3.06	21.18	10.00	204	Ductile		
3870-13	20	061204	061213	32.00	3.07	21.18	9.98	206	Ductile		
3870-14	20	061204	061213	32.00	3.07	21.18	9.98	208	Ductile		
3870-15	20	061204	061211	31.96	2.99	20.50	9.93	156	Ductile		
3870-16	20	061204	061213	32.00	3.00	20.50	9.91	210	Ductile		
3870-17	20	061205	061218	31.99	3.00	20.50	9.90	277	Ductile		
3870-18	20	061205	061219	31.95	3.05	20.79	9.85	341	Ductile		
3870-19	20	061205	061229	32.00	3.06	20.79	9.83	577	Ductile		
3870-20	20	061205	061218	32.00	3.03	20.50	9.80	309	Ductile		
3870-21	20	061205	061222	31.98	2.98	20.10	9.78	398	Ductile		
3870-22	20	061205	061227	31.96	3.04	20.50	9.75	495	Ductile		
3870-23	20	061205	061227	32.00	3.05	20.50	9.73	498	Ductile		
3870-24	20	061205	061225	31.95	3.00	20.10	9.70	442	Ductile		
3870-25	20	061205	070126	31.95	2.98	19.91	9.68	1 237	Ductile		
3870-26	20	061205	070112	31.98	2.99	19.91	9.65	913	Ductile		
3870-27	20	061205	070115	32.00	3.00	19.91	9.62	957	Ductile		
3870-28	20	061205	070104	31.98	3.03	20.10	9.60	709	Ductile		
3870-29	20	061205	070521	32.00	3.04	20.10	9.58	3 973	Ductile		
3870-30	20	061205	070328	32.00	3.02	19.91	9.55	2 701	Ductile		
3870-31	20	061205	070319	31.96	3.05	20.10	9.53	2 461	Ductile		
3870-102	20	061209	071030	32.00	3.06	20.10	9.51	7 785	Ductile		

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-146	20	070419		31.98	3.06	20.10	9.50	->		*>5 856*	
3870-32	20	061205	070817	31.96	3.03	19.91	9.50	6 121	Ductile		
3870-103	20	061209	071105	32.00	2.99	19.42	9.42	7 941	Ductile		
3870-147	20	070419		31.95	3.06	19.91	9.40	->		*>5 856*	
3870-104	20	061209		32.00	3.01	19.42	9.35	->		*>9 000*	
3870-148	20	070419		32.00	2.97	19.03	9.30	->		*>5 856*	
3870-105	20	061209		32.00	3.03	19.42	9.28	->		*>9 000*	
3870-106	20	061209		32.00	3.05	19.42	9.21	->		*>9 000*	
3870-149	20	070419		32.00	3.00	19.03	9.20	->		*>5 856*	
3870-107	20	061209		32.00	2.96	18.63	9.14	->		*>9 000*	
3870-150	20	070419		31.95	3.08	19.42	9.10	->		*>5 856*	
3870-108	20	061209		32.00	2.98	18.63	9.07	->		*>9 000*	
3870-109	20	061209		32.00	3.06	19.03	9.00	->		*>9 000*	
3870-151	20	070419		32.00	3.06	19.03	9.00	->		*>5 856*	
3870-152	20	070419		32.00	3.03	18.63	8.91	->		*>5 856*	
3870-141	20	070104		31.95	3.03	18.63	8.89	->		*>8 376*	
3870-153	20	070419		32.00	2.99	18.24	8.85	->		*>5 856*	

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-33	60	061206	061206	32.00	2.98	14.32	6.97	1	Ductile		
3870-34	60	061206	061206	32.00	3.03	14.51	6.94	1	Ductile		
3870-35	60	061206	061206	32.00	2.98	14.12	6.88	2	Ductile		
3870-36	60	061206	061206	32.00	3.04	14.32	6.82	3	Ductile		
3870-37	60	061206	061206	32.00	3.06	14.32	6.77	4	Ductile		
3870-38	60	061206	061207	32.00	3.05	14.12	6.70	17	Ductile		
3870-203	60	071129	071130	32.00	3.05	14.12	6.70	6	Ductile		
3870-205	60	071129	071201	32.00	3.06	14.12	6.68	40	Ductile		
3870-204	60	071129	071130	32.00	3.00	13.83	6.68	22	Ductile		
3870-206	60	071129	071203	32.00	2.99	13.73	6.66	40	Ductile		
3870-39	60	061206	061207	32.00	3.07	14.12	6.65	19	Ductile		
3870-207	60	071129	071205	32.00	3.02	13.83	6.63	132	Ductile		
3870-208	60	071129	071203	32.00	3.02	13.83	6.63	83	Ductile		
3870-40	60	061206	061208	32.00	3.03	13.83	6.61	37	Ductile		
3870-209	60	071129	071204	32.00	3.01	13.73	6.61	103	Ductile		
3870-210	60	071129	071214	32.00	3.04	13.83	6.59	344	Ductile		
3870-41	60	061206	061211	32.00	3.02	13.73	6.59	85	Ductile		
3870-211	60	071129	071214	32.00	2.97	13.44	6.57	343	Ductile		
3870-43	60	061206	061208	32.00	3.05	13.83	6.56	49	Ductile		
3870-42	60	061206	061221	32.00	3.03	13.73	6.56	349	Ductile		
3870-44	60	061206	061218	32.00	3.04	13.73	6.54	270	Ductile		
3870-212	60	071129		32.00	3.04	13.73	6.54	->		*>480*	
3870-45	60	061206	061219	31.98	3.06	13.83	6.53	301	Ductile		
3870-46	60	061206	061225	31.96	3.05	13.73	6.51	418	Ductile		
3870-47	60	061206	070124	31.96	3.05	13.73	6.51	1 165	Ductile		
3870-48	60	061206	070102	32.00	3.06	13.73	6.49	615	Ductile		
3870-50	60	061206	061215	31.99	3.01	13.44	6.47	205	Ductile		
3870-49	60	061206	070123	32.00	2.97	13.24	6.47	1 141	Ductile		
3870-51	60	061206	070129	32.00	3.02	13.44	6.45	1 261	Ductile		
3870-52	60	061206	070712	32.00	2.99	13.24	6.42	5 233	Ductile		
3870-53	60	061206	070108	31.96	3.03	13.44	6.41	757	Ductile		
3870-54	60	061206	070207	32.00	3.04	13.44	6.40	1 501	Ductile		

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-110	60	061209	070410	32.00	3.04	13.44	6.40	2 885	Ductile		
3870-154	60	070419		32.00	3.04	13.44	6.40	->		*>5 856*	
3870-155	60	070419	070820	32.00	3.02	13.24	6.35	2 953	Ductile		
3870-111	60	061209		32.00	3.03	13.24	6.33	->		*>9 000*	
3870-156	60	070419		32.00	3.04	13.24	6.31	->		*>5 856*	
3870-112	60	061209		32.00	3.05	13.24	6.28	->		*>9 000*	
3870-157	60	070419		31.95	3.09	13.44	6.27	->		*>5 856*	
3870-158	60	070419		31.96	3.03	13.04	6.23	->		*>5 856*	
3870-113	60	061209		32.00	2.97	12.75	6.23	->		*>9 000*	
3870-159	60	070419		32.00	3.01	12.85	6.19	->		*>5 856*	
3870-114	60	061209		32.00	3.02	12.85	6.16	->		*>9 000*	
3870-160	60	070419		32.00	3.01	12.75	6.14	->		*>5 856*	
3870-115	60	061209		32.00	3.02	12.75	6.12	->		*>9 000*	
3870-161	60	070419		31.99	3.03	12.75	6.09	->		*>5 856*	
3870-116	60	061209		32.00	2.96	12.36	6.06	->		*>9 000*	
3870-162	60	070419		32.00	3.05	12.75	6.05	->		*>5 856*	
3870-117	60	061209		32.00	3.03	12.55	6.00	->		*>9 000*	
3870-163	60	070419		32.00	3.03	12.55	6.00	->		*>5 856*	
3870-142	60	070104		31.96	3.03	12.36	5.90	->		*>8 376*	
3870-143	60	070104		31.95	2.97	11.87	5.79	->		*>8 376*	
3870-144	60	070104		31.95	3.01	11.87	5.70	->		*>8 376*	
3870-145	60	070104		31.95	3.03	11.57	5.52	->		*>8 376*	

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-55	95	061207	061207	32.00	3.04	8.83	4.20	0	Ductile		
3870-56	95	061207	061207	32.00	3.02	8.63	4.14	1	Ductile		
3870-57	95	061207	061207	32.00	3.06	8.63	4.08	2	Ductile		
3870-58	95	061207	061207	32.00	2.97	8.24	4.03	2	Ductile		
3870-59	95	061207	061208	32.00	3.01	8.24	3.97	5	Ductile		
3870-60	95	061207	061207	32.00	3.04	8.24	3.92	4	Ductile		
3870-178	95	071126	071128	32.00	3.01	8.04	3.87	38	Ductile		
3870-179	95	071126	071127	32.00	3.01	8.04	3.87	23	Ductile		
3870-180	95	071126	071130	32.00	3.02	8.04	3.86	86	Ductile		
3870-181	95	071126	071129	32.00	3.02	8.04	3.86	66	Ductile		
3870-61	95	061207	061211	32.00	2.96	7.85	3.85	60	Ductile		
3870-62	95	061207	061211	32.00	2.96	7.85	3.85	44	Ductile		
3870-63	95	061207	061211	32.00	2.96	7.85	3.85	52	Ductile		
3870-182	95	071126	071130	32.00	3.03	8.04	3.84	93	Ductile		
3870-183	95	071126	071130	32.00	3.03	8.04	3.84	94	Ductile		
3870-184	95	071126	071212	32.00	3.03	8.04	3.84	378	Ductile		
3870-185	95	071126	071130	32.00	3.03	8.04	3.84	85	Ductile		
3870-186	95	071126	071204	32.00	3.03	8.04	3.84	178	Ductile		
3870-187	95	071126	071203	32.00	3.04	8.04	3.83	157	Ductile		
3870-188	95	071126	071207	32.00	3.04	8.04	3.83	248	Ductile		
3870-189	95	071126	071206	32.00	3.05	8.04	3.82	223	Ductile		
3870-190	95	071126	071128	32.00	3.05	8.04	3.82	33	Ductile		
3870-191	95	071126	071203	32.00	3.05	8.04	3.82	123	Ductile		
3870-192	95	071126	071128	32.00	3.06	8.04	3.80	50	Ductile		
3870-64	95	061207	061219	32.00	3.00	7.85	3.79	264	Ductile		
3870-65	95	061207	061213	32.00	3.00	7.85	3.79	148	Ductile		
3870-66	95	061207	061213	32.00	3.01	7.85	3.78	142	Ductile		
3870-67	95	061207	070110	31.96	3.02	7.85	3.76	817	Ductile		
3870-68	95	061207	070102	31.95	3.02	7.85	3.76	623	Ductile		
3870-69	95	061207	061218	31.95	3.02	7.85	3.76	247	Ductile		
3870-164	95	070419	070724	32.00	3.03	7.85	3.75	2 293	Ductile		
3870-165	95	070419	070511	32.00	2.98	7.65	3.72	517	Ductile		

HYDROSTATIC PRESSURE TESTING

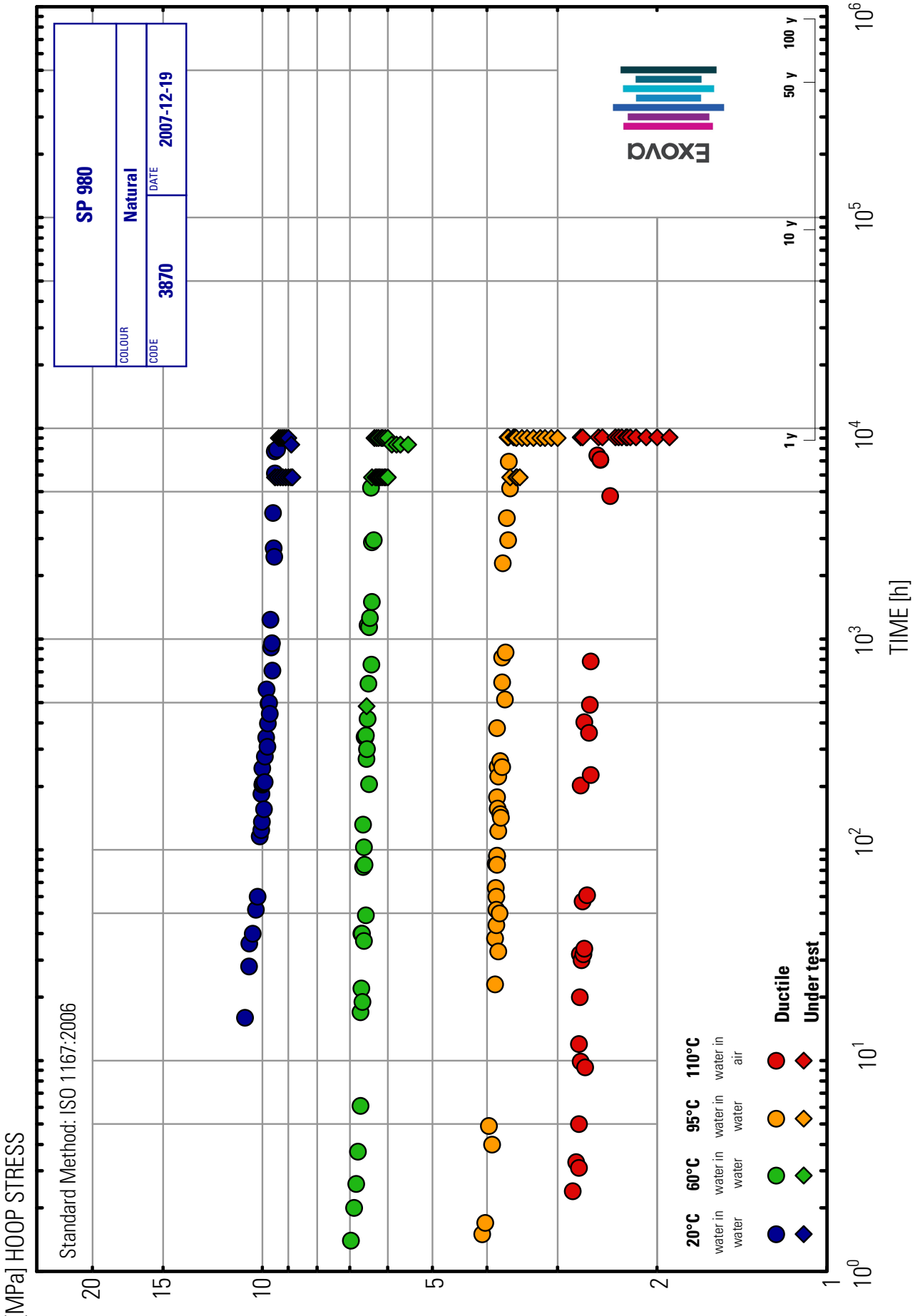
Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-166	95	070419	070525	31.98	3.06	7.85	3.71	865	Ductile		
3870-70	95	061207	070514	31.96	3.00	7.65	3.69	3 757	Ductile		
3870-71	95	061207		32.00	3.01	7.65	3.68	->		*>9 048*	
3870-72	95	061207		32.00	3.02	7.65	3.67	->		*>9 048*	
3870-73	95	061207		31.98	3.02	7.65	3.67	->		*>9 048*	
3870-167	95	070419	070820	32.00	3.02	7.65	3.67	2 953	Ductile		
3870-74	95	061207	070924	31.95	3.02	7.65	3.66	6 957	Ductile		
3870-168	95	070419		31.96	3.04	7.65	3.64	->		*>5 856*	
3870-169	95	070419	071122	31.95	3.04	7.65	3.64	5 197	Ductile		
3870-75	95	061207		32.00	3.01	7.45	3.59	->		*>9 048*	
3870-76	95	061207		31.98	3.02	7.45	3.57	->		*>9 048*	
3870-118	95	061209		32.00	3.04	7.45	3.55	->		*>9 000*	
3870-170	95	070419		32.00	3.04	7.45	3.55	->		*>5 856*	
3870-171	95	070419		32.00	3.04	7.45	3.55	->		*>5 856*	
3870-172	95	070419		31.95	3.04	7.45	3.54	->		*>5 856*	
3870-173	95	070419		32.00	3.04	7.36	3.50	->		*>5 856*	
3870-119	95	061209		32.00	2.99	7.16	3.47	->		*>9 000*	
3870-120	95	061209		32.00	3.05	7.16	3.40	->		*>9 000*	
3870-121	95	061209		32.00	3.01	6.86	3.31	->		*>9 000*	
3870-122	95	061209		32.00	3.00	6.67	3.22	->		*>9 000*	
3870-123	95	061209		32.00	2.97	6.47	3.16	->		*>9 000*	
3870-124	95	061209		32.00	3.04	6.47	3.08	->		*>9 000*	
3870-125	95	061209		32.00	3.05	6.33	3.00	->		*>9 000*	

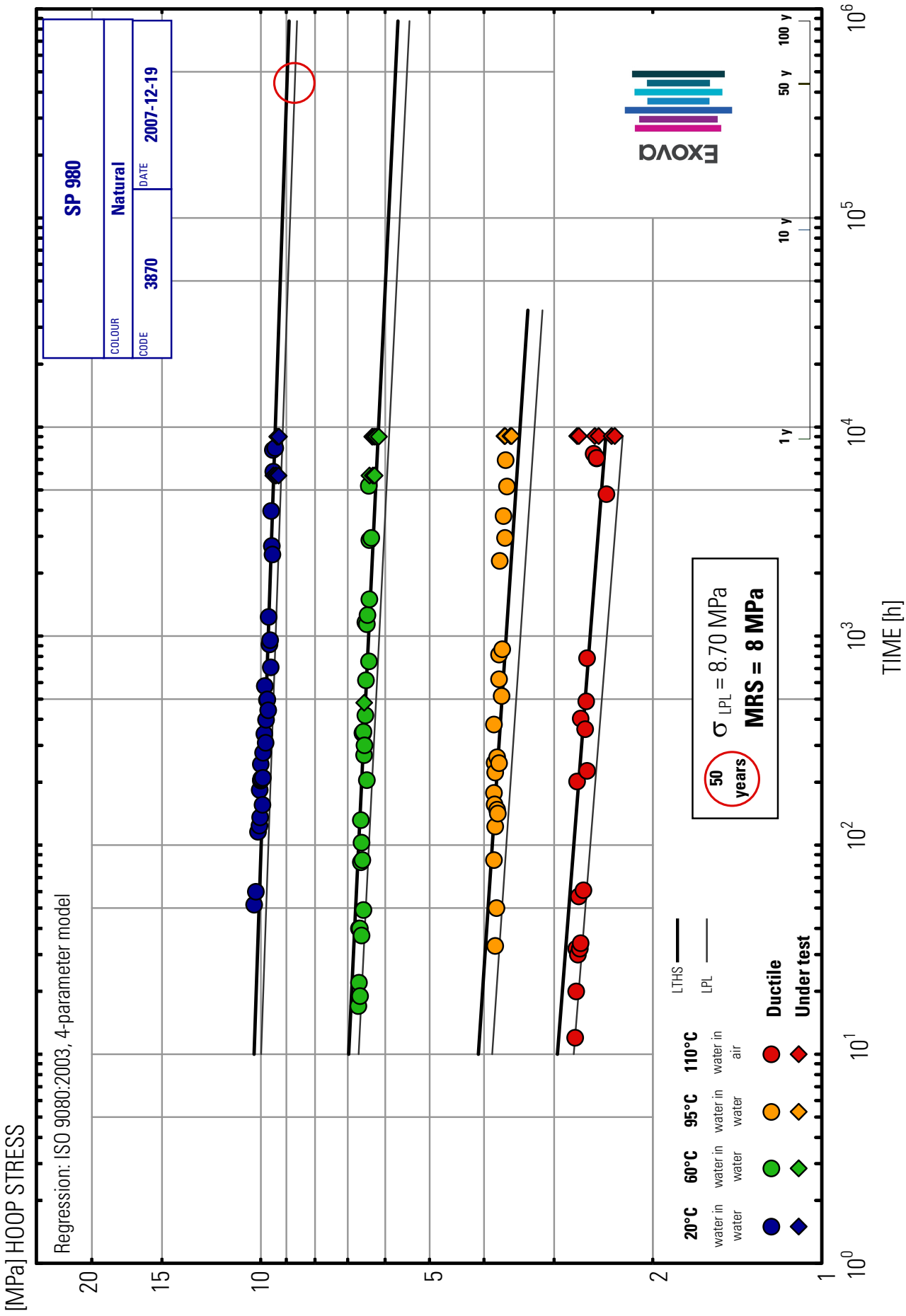
HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-77	110	061207	061207	32.00	3.02	5.88	2.82	2	Ductile		
3870-78	110	061207	061208	32.00	3.02	5.79	2.78	3	Ductile		
3870-174	110	070419	070420	31.98	3.04	5.79	2.75	12	Ductile		
3870-193	110	071126	071127	32.00	3.05	5.79	2.75	5	Ductile		
3870-194	110	071126	071126	32.00	3.00	5.69	2.75	3	Ductile		
3870-195	110	071126	071128	32.00	3.01	5.69	2.74	32	Ductile		
3870-196	110	071126	071127	32.00	3.01	5.69	2.74	20	Ductile		
3870-79	110	061207		32.00	3.02	5.69	2.73	->		*>9 048*	
3870-175	110	070419	070429	31.99	3.02	5.69	2.73	202	Ductile		
3870-197	110	071126	071127	32.00	3.02	5.69	2.73	10	Ductile		
3870-198	110	071126	071128	32.00	3.03	5.69	2.72	30	Ductile		
3870-80	110	061207		32.00	3.04	5.69	2.71	->		*>9 048*	
3870-199	110	071126	071129	32.00	3.04	5.69	2.71	57	Ductile		
3870-176	110	070419	070423	31.99	3.05	5.69	2.70	32	Ductile		
3870-200	110	071126	071128	32.00	3.06	5.69	2.69	34	Ductile		
3870-201	110	071126	071213	32.00	3.06	5.69	2.69	404	Ductile		
3870-202	110	071126	071127	32.00	3.07	5.69	2.68	9	Ductile		
3870-177	110	070419	070423	31.95	3.09	5.69	2.66	61	Ductile		
3870-126	110	061212	070109	32.00	3.00	5.49	2.65	671	Ductile		*1*
3870-81	110	061207	061222	32.00	3.01	5.49	2.64	359	Ductile		
3870-82	110	061207	061228	32.00	3.03	5.49	2.63	488	Ductile		
3870-83	110	061207	070109	32.00	3.04	5.49	2.62	784	Ductile		
3870-84	110	061207	061218	31.99	3.04	5.49	2.62	227	Ductile		
3870-127	110	061212	070208	32.00	3.05	5.49	2.61	1 379	Ductile		*2*
3870-85	110	061207	071015	32.00	3.01	5.30	2.55	7 451	Ductile		
3870-86	110	061207		32.00	3.02	5.30	2.54	->		*>9 048*	
3870-128	110	061212	070407	32.00	3.03	5.30	2.53	2 759	Ductile		*2*
3870-87	110	061207	070928	31.98	3.04	5.30	2.52	7 079	Ductile		
3870-88	110	061207	071001	31.95	3.04	5.30	2.52	7 115	Ductile		
3870-89	110	061207		32.00	3.01	5.20	2.50	->		*>9 048*	
3870-129	110	061212	070122	32.00	2.97	5.10	2.49	947	Ductile		*2*
3870-130	110	061212		32.00	3.03	5.10	2.44	->		*>8 928*	*2*

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	σ	Failure time	Failure mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
3870-90	110	061207	070719	32.00	3.04	5.10	2.43	0	Stopped		*3*
3870-91	110	061207	070624	31.95	3.04	5.10	2.42	4 780	Ductile		
3870-92	110	061207		31.95	3.00	4.90	2.37	->		*>9 048*	
3870-131	110	061212		32.00	3.01	4.90	2.36	->		*>8 928*	*2*
3870-93	110	061207		31.99	3.03	4.90	2.34	->		*>9 048*	
3870-132	110	061212		32.00	3.03	4.90	2.34	->		*>8 928*	*2*
3870-94	110	061207		31.95	3.06	4.90	2.31	->		*>9 048*	
3870-95	110	061207		31.95	3.00	4.71	2.27	->		*>9 048*	
3870-133	110	061212		32.00	3.01	4.71	2.27	->		*>8 928*	*2*
3870-96	110	061207		32.00	3.02	4.71	2.26	->		*>9 048*	
3870-134	110	061212		32.00	3.03	4.71	2.25	->		*>8 928*	*2*
3870-97	110	061207		31.95	3.05	4.71	2.23	->		*>9 048*	
3870-98	110	061207		32.00	3.00	4.51	2.18	->		*>9 048*	
3870-135	110	061212		32.00	3.03	4.51	2.16	->		*>8 928*	*2*
3870-99	110	061207		32.00	3.00	4.32	2.09	->		*>9 048*	
3870-136	110	061212		32.00	3.01	4.32	2.08	->		*>8 928*	*2*
3870-137	110	061212		32.00	3.03	4.32	2.06	->		*>8 928*	*2*
3870-100	110	061207		32.00	2.99	4.12	2.00	->		*>9 048*	
3870-138	110	061212		32.00	3.01	4.12	1.98	->		*>8 928*	*2*
3870-139	110	061212		32.00	3.03	4.02	1.92	->		*>8 928*	*2*
3870-101	110	061207		32.00	3.06	4.02	1.90	->		*>9 048*	
3870-140	110	061212		32.00	3.01	3.92	1.89	->		*>8 928*	*2*


SP 980
Natural
3870
2007-12-19
COLOUR
CODE
DATE
EXOVA
[MPa] HOOP STRESS
Standard Method: ISO 1167:2006
TIME [h]
20
15
10
5
2
1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
1 y
10 y
50 y
100 y
20°C water in water
60°C water in water
95°C water in water
110°C water in air
Ductile
Under test


SP 980
Natural
COLOUR
3870
CODE
2007-12-19
DATE
EXOVA
[MPa] HOOP STRESS
Regression: ISO 9080:2003, 4-parameter model
TIME [h]
20
15
10
5
2
1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
1 y
10 y
50 y
100 y
LTHS
LPL
20°C water in water
60°C water in water
95°C water in water
110°C water in air
Ductile
Under test
50 years
σ_{LPL} = 8.70 MPa
MRS = 8 MPa

EXOVA/P-12/110

DETERMINATION OF THE LONG-TERM HYDROSTATIC STRENGTH
ISO 9080:2003-evaluation of the PE-RT pipe grade SP 980 Natural from LG Chem, Ltd.

Mattias SVEDBERG

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