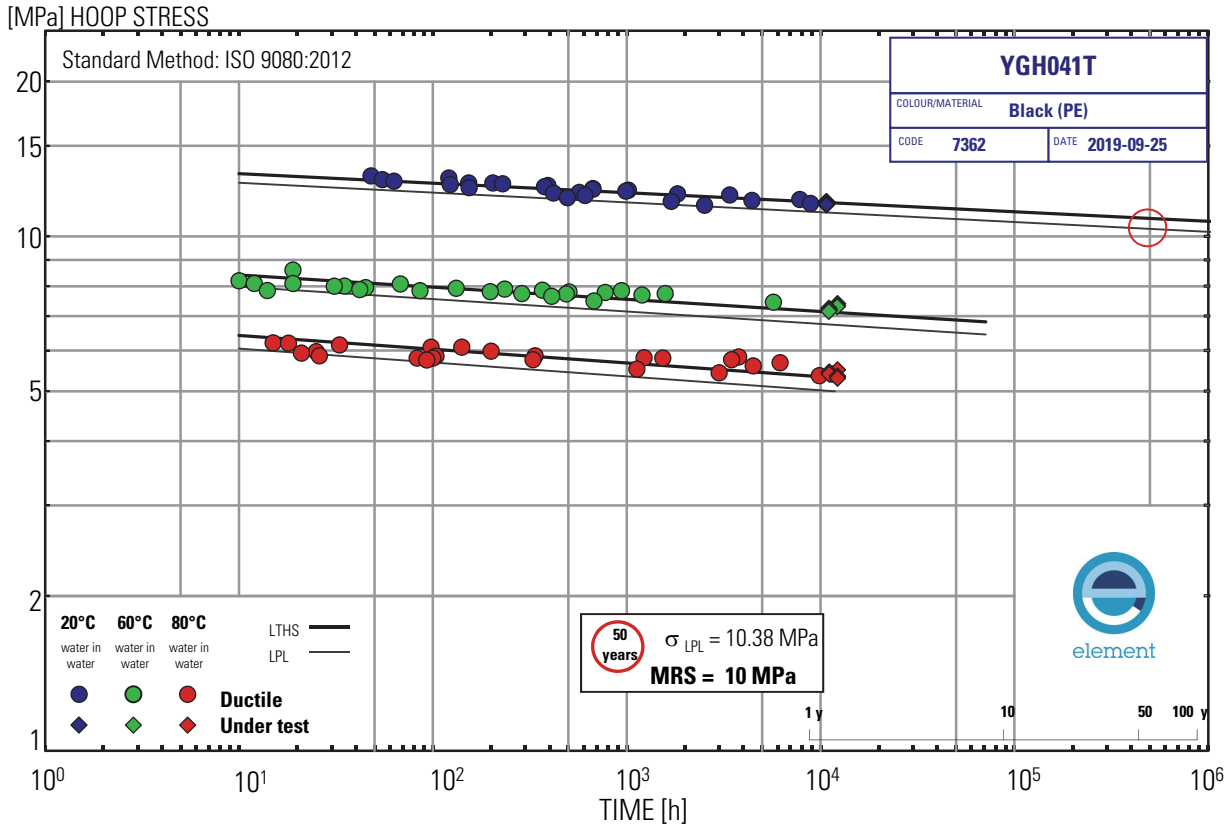
ELEMENT TEST REPORT P-19/56-v1

TYPE TESTING

Type testing (TT) of the black PE pipe compound YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd. according to CEN/TS 1555-7:2013 covering also ISO 4437-1:2014



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P-11056

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TYPE TESTING
Type testing (TT) of the black PE pipe compound YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd. according to CEN/TS 1555-7:2013 covering also ISO 4437-1:2014

ABSTRACT

The aim of this project was to perform type testing (TT) of the black PE pipe compound YGH041T according to CEN/TS 1555-7:2013 covering also ISO 4437-1:2014.

CHARACTERISTIC	METHOD	UNIT	REQUIREMENT	RESULT	PASS
Compound density	ISO 1183-1:2004 (A)	[kg/m^3]	≥930	959.8	PASS
Carbon black content	ISO 6964:1986	[wt %]	2.0-2.5	2.1	PASS
Carbon black dispersion	ISO 18553:2002	Grade	≤3	2.1	PASS
Carbon black dispersion	ISO 18553:2002	Rating	A1, A2, A3, B	A2	PASS
Melt mass flow rate (5 kg/190°C)	ISO 1133-1:2011	[g/10 min]	0.2-1.4	0.32	PASS
Oxidation induction time (200°C)	ISO 11357-6:2013	[min]	≥20	95	PASS
Volatile content	EN 12099:1997	[mg/kg]	≤350	150	PASS
Tensile strength for butt-fusion	ISO 13953:2001	-	Ductile	Ductile	PASS
RCP-S4 (250 mm SDR 11)	ISO 13477:2008	[bar]	10*	≥10	PASS
Resistance to slow crack growth	ISO 13479:2009	[h]	500	1 189 h	PASS
Gas condensate resistance	ISO 4437-1:2014	[h]	≥20	>20	PASS
MRS Classification	ISO 12162:2009	[MPa]	10	10	PASS

* *The requirement in EN 1555-1:2014 is 3.4 bar (using a design coefficient, C, of 2).*

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APPENDICES

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JUNIOR PROJECT MANAGER

Approved by

Jarno Hassinen
OPERATIONS MANAGER

1 EVALUATED PIPE COMPOUND IN ISO 9080

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

EVALUATED PIPE COMPOUND	
TRADE NAME	YGH041T
COLOUR	Black
MATERIAL	PE
NOMINAL DIMENSION	32 x 3 mm
ELEMENT CODE	7362
NO OF SAMPLES TESTED	134

2 EXPERIMENTAL PROCEDURE FOR ISO 9080

The hydrostatic pressure testing is performed at Element according to ISO 1167:2006. The pressure testing at 20, 60 and 80°C is performed using deionised water on the inside and on the outside of the pipe specimens. 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 ±0.02 mm and the diameter[1] within ±0.1 mm.

3 RESULTS FROM THE HYDROSTATIC PRESSURE TESTING FOR ISO 9080

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

SUMMARY OF THE RESULTS FROM THE HYDROSTATIC PRESSURE TESTING						
T	**TOTAL**	**BURST**	**ON TEST**	**STOPPED**	**LONGEST TIME TO BURST**	**LONGEST TEST TIME**
20°C	46	34	12	0	8 878 h	12 235 h
60°C	47	35	12	0	5 711 h	12 234 h
80°C	41	32	9	0	11 510 h	12 234 h

[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-4/02 and is documented at ELEMENT.

4 ISO 9080-EVALUATION METHODOLOGY

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 latest version of the software Pipeson Analyzer from Pipeson.

The ISO 9080 also includes extrapolation factors that determine to what times we can extrapolate at each temperature.

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 36 h at 20°C were excluded from the analysis in accordance with paragraph 4.2.3 in ISO 9080.

5.2 Distribution of stress rupture data

The table below presents the distribution of observations for the data set that was used in the ISO 9080-evaluation.

DISTRIBUTION OF THE STRESS RUPTURE DATA INCLUDED IN THE ISO 9080 EVALUATION							
T	**TOTAL**	**BURST**	**ONGOING**	**STOPPED**	**>7 000 h**	**>9 000 h**	**EXCLUDED**[2)]
20°C	30	26	4	0	6	4	0
60°C	31	25	6	0	6	6	0
80°C	30	25	5	0	7	7	0
Requirement[1)]	*30*	-	-	-	*4*	*1*	-

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

2) Number of pipe samples 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. The table below presents the regression coefficients and the standard error values for the selected analysis.

REGRESSION COEFFICIENTS FOR THE SELECTED MODEL				
FIRST BRANCH	**C_1**	**C_2**	**C_3**	**C_4**
VALUE	-116.100	52 048.855	42.446	-28 235.080
STANDARD ERROR	11.391	4 383.529	8.715	3 343.481

5.4 Extrapolation time limits

The tables below show the maximum test times and the maximum extrapolation time limits for the different test temperatures.

MAXIMUM TEST TIMES		
T_t[1)]	**t_{max}**[2)]	
20°C	10 327 h	1.18 yrs
60°C	11 749 h	1.34 yrs
80°C	11 849 h	1.35 yrs

1) T_t is the test temperature

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

MAXIMUM EXTRAPOLATION TIME LIMITS		
T_s[1)]	**EXTRAPOLATION TIME LIMIT, t_e**[2)]**, AT T_s**	
20°C	1 184 895 h	135 yrs
60°C	71 094 h	8.12 yrs
80°C	11 849 h	1.35 yrs

1) T_s is the service temperature (the extrapolated temperature)

2) The extrapolation time limit, t_e, is calculated from the relation: $t_e = t_{max} \cdot k_e$, k_e is the extrapolation time factor and is a function of the difference in extrapolated temperature, T_s, and the test temperature, T_t.

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.

EXTRAPOLATED STRENGTH VALUES						
TIME	σ_{LTHS} [MPa]			σ_{LPL}[MPa]		
	20°C	60°C	80°C	20°C	60°C	80°C
10 h	13.248	8.414	6.419	12.713	7.987	6.053
100 h	12.693	7.968	6.037	12.186	7.565	5.693
1 000 h	12.162	7.546	5.677	11.672	7.159	5.349
10 000 h	11.653	7.146	5.339	11.170	6.769	5.022
100 000 h	11.166	-	-	10.682	-	-
50 yrs	10.864	-	-	10.376	-	-
100 yrs	10.725	-	-	10.235	-	-

EXTRAPOLATED STRENGTH VALUES AT t_e				
T	t_e	t_e	σ_{LTHS}	σ_{LPL}
20°C	1 184 895 h	135 yrs	10.665 MPa	10.174 MPa
60°C	71 094 h	8.12 yrs	6.822 MPa	6.449 MPa
80°C	11 849 h	1.35 yrs	5.315 MPa	4.998 MPa

5.6 Classification and designation according to ISO 12162

By its LPL value of 10.38 MPa at 20°C and 50 years the black PE pipe compound YGH041T has a minimum required strength (MRS) classification of 10 MPa and is thereby designated PE 100 according to ISO 12162:2009.

6 EVALUATION OF THE COMPPOND CHARCERITICS

The evaluation of the compound characteristics has been performed Element and its subcontractors according to the table below.

CHARACTERISTICS ANALYSIS CONDUCTED ON GRANULES		
CHARACTERISTIC	**TEST INSTITUTE**	**REFERENCE**
Compound density	RISE	8F010588
Carbon black content	RISE	8F010588
Carbon black dispersion	RISE	8F010588/9F030163
Melt mass flow rate (5 kg/190°C)	RISE	8F010588
OIT (200°C)	RISE	8F010588
Volatile content	RISE	8F010588
Tensile strength for butt-fusion	RISE	8F010588
Gas condensate resistance	RISE	8F010588
RCP-S4 (250 mm SDR 11)	Element	P-18/156-v1
Resistance to slow crack growth	Element	P-18/157-v1

The testing has been done on granule and on pipe samples.

CHARACTERISTICS ANALYSIS CONDUCTED ON GRANULES					
CHARACTERISTIC	**METHOD**	**UNIT**	**REQUIREMENT**	**RESULT**	**PASS**
EVALUATION PERFOMRED ON GRANULES					
Compound density	ISO 1183-1:2004	[kg/m^3]	≥930	959.8	PASS
Carbon black content	ISO 6964:1986	[wt %]	2.0-2.5	2.1	PASS
Carbon black dispersion	ISO 18553:2002	Grade	≤3	2.1	PASS
Carbon black dispersion	ISO 18553:2002	Rating[a)]	A1, A2, A3 or B	A2	PASS
Melt mass flow rate (5 kg/190°C)	ISO 1133:2011	[g/10 min]	0.2-1.4	0.32	PASS
OIT (200°C)	ISO 11357-6:2013	[min]	≥20	95	PASS
Volatile content	EN 12099:1997	[mg/kg]	≤350	150	PASS
EVALUATION PERFOMRED ON PIPES					
Tensile strength for butt-fusion	ISO 13953:2001	-	Ductile	Ductile	PASS
RCP-S4 (250 mm SDR 11)	ISO 13477:2008	[bar]	10[b)]	>10	PASS
Resistance to slow crack growth	ISO 13479:2009	[h]	500	1 189	PASS
Gas condensate resistance	ISO 4437-1:2014	[h]	≥20	>20	PASS

7 ADDITIONAL COMMENTS

The delivered pipes showed good visual appearance and no unusual behaviour were observed during the hydrostatic pressure testing.

The carbon black dispersion was re-evaluated in report 9F030163.

The results in this report are only valid for the material with Element codes 7360, 7361, 7362 and 7363.

Note, the effect on water quality tests have not been performed as this a national requirement.

8 VERSION HISTORY

The latest version replaces any preceding version of the report.

VERSION	DATE	CHANGES
v1	2019-09-25	-

9 REFERRED DOCUMENTS

DOCUMENT	VERSION	TITLE
EA-4/16	2003	EA guidelines on the expression of uncertainty in quantitative testing
EN 12099	1997	Plastics piping systems - Polyethylene piping materials and components - Determination of volatile content
Element report	P-18/156-v1	RAPID CRACK PROPAGATION – CRITICAL PRESSURE Determination of resistance to rapid crack propagation (RCP) according to ISO 13477 (S4-test) of the black PE pipe grade YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.
Element report	P-18/157-v1	NOTCH PIPE TESTING Notch pipe testing according to ISO 13479 of the black PE pipe grade YGH041T from YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.
ISO 1133	2011	Plastics - Determination of the melt mass-flow rate (MFR) and the melt volume-flow rate (MVR) of thermoplastics
ISO 11357	2013	Plastics – Differential scanning calorimetry (DSC) - Part 6 Determination of oxidation induction time (isothermal OIT) and oxidation induction temperature (dynamic OIT)
ISO 1167	2006	Thermoplastics pipes, fittings and assemblies for the conveyance of fluids – Determination of the resistance to internal pressure
ISO 1183	2004	Methods for determining the density of non-cellular plastics
ISO 12162	2009	Thermoplastics materials for pipes and fittings for pressure applications – Classification, designation and design coefficient
ISO 13477	2008	Thermoplastics pipes for the conveyance of fluids – Determination of resistance to rapid crack propagation (RCP) – Small-scale steady-state test (S4 test)
ISO 13953	2001	Polyethylene (PE) pipes and fitting. Determination of the tensile strength and failure mode of test pieces from a butt-fused joint
ISO 18553	2002	Method for the assessment of the degree of pigment or carbon black dispersion in polyolefin pipes, fittings and compounds
ISO 4437	2014	Plastics piping systems — Plastics piping systems for the supply of gaseous fuels – Polyethylene (PE)
ISO 6964	1986	Polyolefin pipes and fittings -- Determination of carbon black content by calcination and pyrolysis -- Test method and basic specification
ISO 9080	2012	Plastics piping and ducting systems –Determination of the long-term hydrostatic strength of thermoplastics materials in pipe form by extrapolation
CEN/TS 1555-7	2013	Plastics piping systems for the supply of gaseous fuels – Polyethylene (PE) – Part 7: Guidance for the assessment of conformity
ISO/IEC 17025	2018	General requirements for the competence of testing and calibration laboratories
Pipeson Analyzer®	3.2.6	ISO 9080 evaluation software from Pipeson AB, SE-11152 Stockholm, Sweden
RISE report	8F010588	Testing of PE-material and butt-fusion joints according to ISO 4437-1:2014
RISE report	9F030163	Determination of carbon black dispersion according to ISO 18553:2002

CLIENT INFO

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MATERIAL INFO

Element code	7362
Trade name	YGH041T
Material	PE
Colour	Black
Nominal dimension	32 x 3 mm
Arrival date at Element	2018-04-03
Amount	202 x 350 mm
Consignor	Shanghai Shenglan Chemical Mechanical and Electrical Equipment Co.,Ltd.
Condition of material at arrival	Good visual appearance
Marking	YGH041T
Resin producer	SINOPEC Shanghai Petrochemical Co., 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	Element Materials Technology, ISO/IEC 17025 Swedac accreditation no. 0067
Responsible	Jarno HASSINEN - Technical Supervisor
Test method	ISO 1167:2006
Length (total/free)	350/310 mm for samples fitted with brass fittings
Fittings	Brass fittings and type A, unless remarked
Internal medium	Water
External medium	Water
Conditioning time	3 h at 20, 60 and 80°C
Situation on	2019-09-25

TABLE REMARKS

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

PIPE REMARKS

1 At temperatures ≤ 40 °C, failure times up to 1 000 h may be neglected, provided that the number of remaining observations conforms to 4.2.1. In that case, all points under the selected time and temperature shall be discarded.

2 The sample was excluded as the time to burst was not registered with an accuracy less or equal to 0.5% as required in ISO 1167:2006

The sample is included in the ISO 9080 evaluation as data type A

TEST INTERRUPTIONS

SAMPLE	DATE	TEST TIME	RESTARTED AFTER	STATUS
7362-73	2019-02-17	5 808 h	27 h	Ok
7362-88	2019-02-17	6 960 h	27 h	Ok
7362-182	2019-02-17	5 808 h	27 h	Ok

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	**s**	Burst time	Burst mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
7362-63	20	180411	180413	32.41	3.09	27.85	13.21	36	Ductile		*1*
7362-67	20	180411	180413	32.30	3.15	28.34	13.11	48	Ductile		
7362-12	20	180411	180417	32.33	3.13	27.85	12.99	121	Ductile		
7362-60	20	180411	180416	32.42	3.08	27.07	12.89	55	Ductile		
7362-66	20	180411	180416	32.41	3.10	27.07	12.80	63	Ductile		
7362-23	20	180411	180418	32.30	3.11	27.07	12.70	153	Ductile		
7362-120	20	181211	181220	32.30	3.11	27.07	12.70	204	Ductile		
7362-56	20	181211	181221	32.31	3.15	27.36	12.66	229	Ductile		
7362-167	20	181211	181217	32.41	3.11	26.77	12.61	123	Ductile		
7362-33	20	180411	180418	32.28	3.10	26.77	12.60	158	Ductile		*2*
7362-131	20	181211	181228	32.30	3.11	26.77	12.56	392	Ductile		
7362-5	20	180411	180424	32.25	3.15	27.07	12.50	296	Ductile		*2*
7362-47	20	181211	181227	32.32	3.16	27.07	12.49	377	Ductile		
7362-111	20	181211	181218	32.43	3.12	26.48	12.44	154	Ductile		
7362-114	20	180411	180416	32.44	3.13	26.48	12.40	75	Ductile		*2*
7362-146	20	181211	190108	32.31	3.12	26.48	12.39	670	Ductile		
7362-16	20	181211	190108	32.30	3.16	26.77	12.35	670	Ductile		
7362-21	20	180411	180417	32.43	3.11	26.09	12.30	141	Ductile		*2*
7362-162	20	181211	190123	32.43	3.11	26.09	12.30	1 020	Ductile		
7362-100	20	181211	190122	32.30	3.15	26.48	12.25	991	Ductile		
7362-4	20	180411	180507	32.25	3.16	26.48	12.19	595	Ductile		*2*
7362-29	20	181211	190104	32.40	3.07	25.50	12.18	570	Ductile		
7362-126	20	181211	190102	32.40	3.08	25.50	12.14	419	Ductile		
7362-24	20	180411	180516	32.29	3.14	26.09	12.11	825	Ductile		*2*
7362-191	20	181211	190226	32.42	3.08	25.40	12.10	1 830	Ductile		
7362-49	20	181211	190502	32.32	3.16	26.09	12.04	3 403	Ductile		
7362-113	20	181211	190107	32.42	3.11	25.50	12.01	610	Ductile		
7362-74	20	180411	180528	32.29	3.10	25.50	12.00	1 083	Ductile		*2*
7362-133	20	180705	180726	32.43	3.13	25.40	11.89	495	Ductile		
7362-43	20	180705	190527	32.31	3.15	25.50	11.80	7 824	Ductile		
7362-55	20	180705	190107	32.30	3.15	25.40	11.75	4 426	Ductile		
7362-15	20	180503	180713	32.43	3.11	24.81	11.70	1 700	Ductile		

HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	**s**	Burst time	Burst mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
7362-70	20	180705		32.31	3.14	25.11	11.66	->		*>10 725*	
7362-112	20	180705		32.30	3.14	25.11	11.66	->		*>10 725*	
7362-98	20	180503	190508	32.33	3.16	25.11	11.59	8 878	Ductile		
7362-101	20	180705		32.34	3.16	25.11	11.59	->		*>10 725*	
7362-72	20	180705		32.42	3.08	24.22	11.54	->		*>10 725*	
7362-168	20	180503	180816	32.46	3.16	24.81	11.50	2 521	Ductile		
7362-11	20	180503		32.30	3.10	24.22	11.41	->		*>12 235*	
7362-164	20	180503		32.37	3.11	24.03	11.30	->		*>12 235*	
7362-53	20	180503		32.43	3.11	23.73	11.19	->		*>12 235*	
7362-40	20	180503		32.29	3.15	24.03	11.11	->		*>12 235*	
7362-42	20	180503		32.29	3.12	23.54	11.00	->		*>12 235*	
7362-13	20	180503		32.32	3.15	23.54	10.90	->		*>12 235*	
7362-48	20	180503		32.43	3.13	23.05	10.79	->		*>12 235*	
7362-10	20	180503		32.42	3.10	22.65	10.71	->		*>12 235*	

HYDROSTATIC PRESSURE TESTING

Code	T [°C]	Start date [yymmdd]	Reg date [yymmdd]	d_{em} [mm]	e_{min} [mm]	p [bar]	**S** [MPa]	Burst time [h]	Burst mode	Test time [h]	Remark
7362-32	60	180412	180413	32.32	3.16	18.63	8.60	19	Ductile		
7362-36	60	180412	180412	32.41	3.11	18.04	8.50	0.8	Ductile		
7362-121	60	180412	180413	32.41	3.08	17.65	8.40	2.9	Ductile		
7362-71	60	180412	180412	32.43	3.12	17.65	8.29	1.4	Ductile		
7362-1	60	180412	180413	32.32	3.14	17.65	8.20	10.0	Ductile		
7362-27	60	180412	180413	32.29	3.11	17.26	8.10	19	Ductile		
7362-143	60	190114	190115	32.42	3.09	17.06	8.10	12	Ductile		
7362-115	60	190114	190117	32.28	3.05	16.87	8.08	68	Ductile		
7362-31	60	190114	190115	32.39	3.07	16.87	8.05	8.2	Ductile		
7362-141	60	190114	190115	32.41	3.08	16.87	8.03	9.1	Ductile		
7362-109	60	190114	190116	32.38	3.02	16.48	8.01	35	Ductile		
7362-94	60	180412	180416	32.26	3.11	17.06	8.00	31	Ductile		
7362-149	60	190114	190115	32.42	3.09	16.87	8.00	7.0	Ductile		
7362-183	60	190114	190116	32.42	3.11	16.87	7.95	45	Ductile		
7362-3	60	180412	180418	32.31	3.14	17.06	7.93	120	Ductile		*2*
7362-138	60	190114	190121	32.29	3.07	16.67	7.93	132	Ductile		
7362-45	60	181206	181217	32.33	3.15	17.06	7.90	235	Ductile		
7362-104	60	181206	181210	32.44	3.17	17.06	7.88	42	Ductile		
7362-165	60	181206	181223	32.32	3.10	16.67	7.86	368	Ductile		
7362-192	60	190314	190315	32.42	3.08	16.48	7.85	14	Ductile		
7362-128	60	181206	190115	32.32	3.14	16.87	7.84	941	Ductile		
7362-181	60	190314	190318	32.41	3.08	16.48	7.84	86	Ductile		
7362-79	60	180412	180423	32.31	3.15	16.87	7.81	235	Ductile		*2*
7362-178	60	181206	181217	32.40	3.04	16.18	7.81	198	Ductile		
7362-150	60	190314	190404	32.31	3.12	16.67	7.80	504	Ductile		
7362-30	60	181206	190108	32.31	3.16	16.87	7.78	775	Ductile		
7362-17	60	180503	180709	32.32	3.11	16.48	7.74	1 582	Ductile		
7362-86	60	181206	181218	32.42	3.12	16.48	7.74	288	Ductile		
7362-174	60	181206	181227	32.31	3.11	16.48	7.73	488	Ductile		
7362-26	60	180412	180601	32.31	3.16	16.67	7.69	1 199	Ductile		
7362-78	60	180503	180521	32.43	3.10	16.18	7.65	411	Ductile		
7362-62	60	180412	180426	32.42	3.11	16.18	7.62	335	Ductile		*2*

HYDROSTATIC PRESSURE TESTING

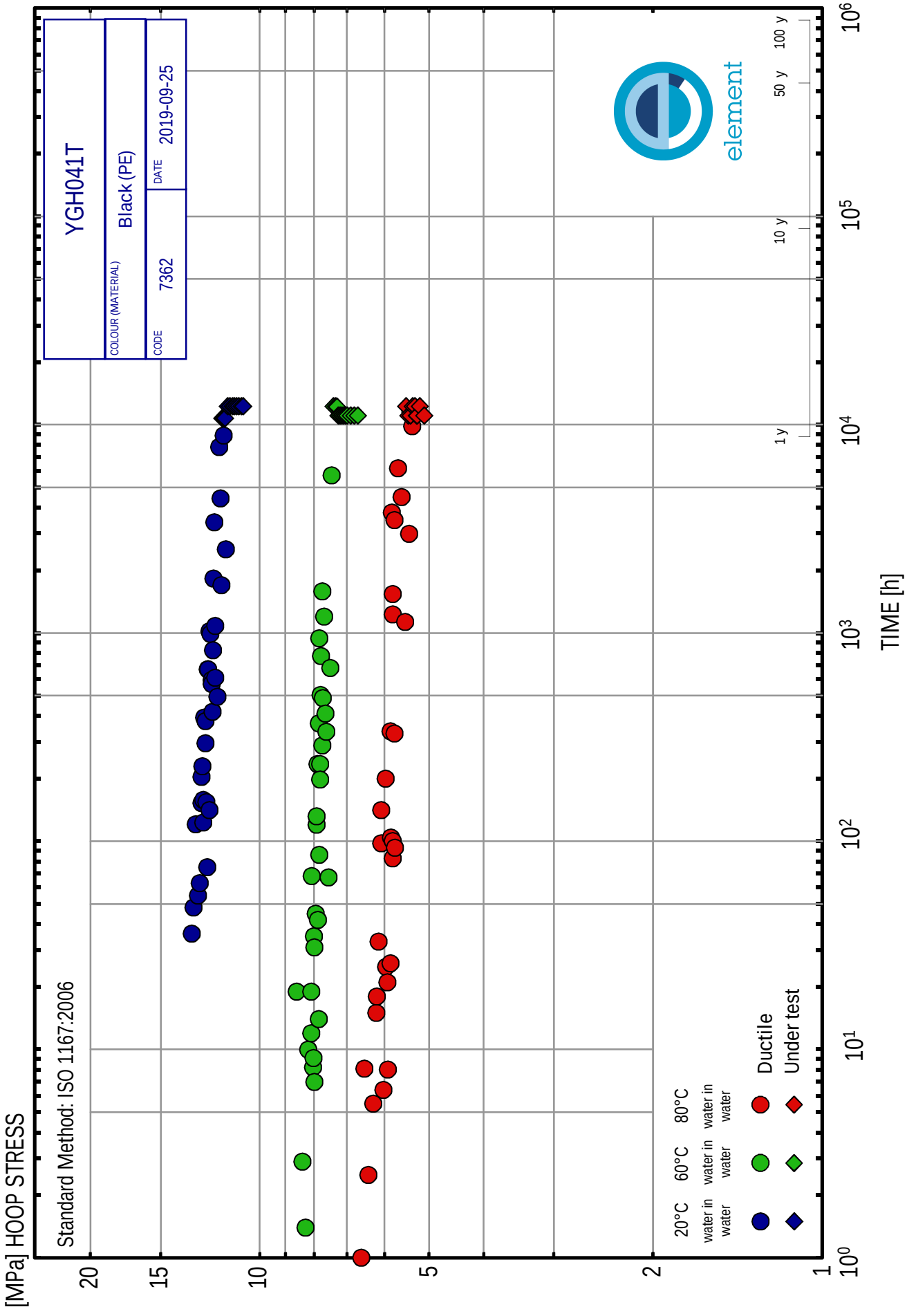
Code	T	Start date	Reg date	d_{em}	e_{min}	p	**s**	Burst time	Burst mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
7362-122	60	180503	180507	32.43	3.14	16.18	7.55	67	Ductile		*2*
7362-18	60	180503	180601	32.42	3.11	15.89	7.49	678	Ductile		
7362-50	60	180503	181227	32.27	3.11	15.89	7.45	5 711	Ductile		
7362-158	60	180503		32.34	3.10	15.69	7.40	->		*>12 234*	
7362-65	60	180503		32.30	3.12	15.69	7.34	->		*>12 234*	
7362-88	60	180503		32.42	3.11	15.50	7.30	->		*>12 207*	
7362-73	60	180620		32.32	3.19	15.89	7.25	->		*>11 055*	
7362-137	60	180620		32.43	3.08	15.10	7.20	->		*>11 082*	
7362-182	60	180620		32.34	3.09	15.10	7.15	->		*>11 055*	
7362-140	60	180620		32.31	3.18	15.50	7.10	->		*>11 082*	
7362-92	60	180620		32.42	3.10	14.91	7.05	->		*>11 082*	
7362-44	60	180620		32.40	3.08	14.71	7.00	->		*>11 082*	
7362-136	60	180620		32.32	3.04	14.32	6.90	->		*>11 082*	
7362-117	60	180620		32.41	3.05	14.12	6.80	->		*>11 082*	
7362-129	60	180620		32.42	3.09	14.12	6.70	->		*>11 082*	

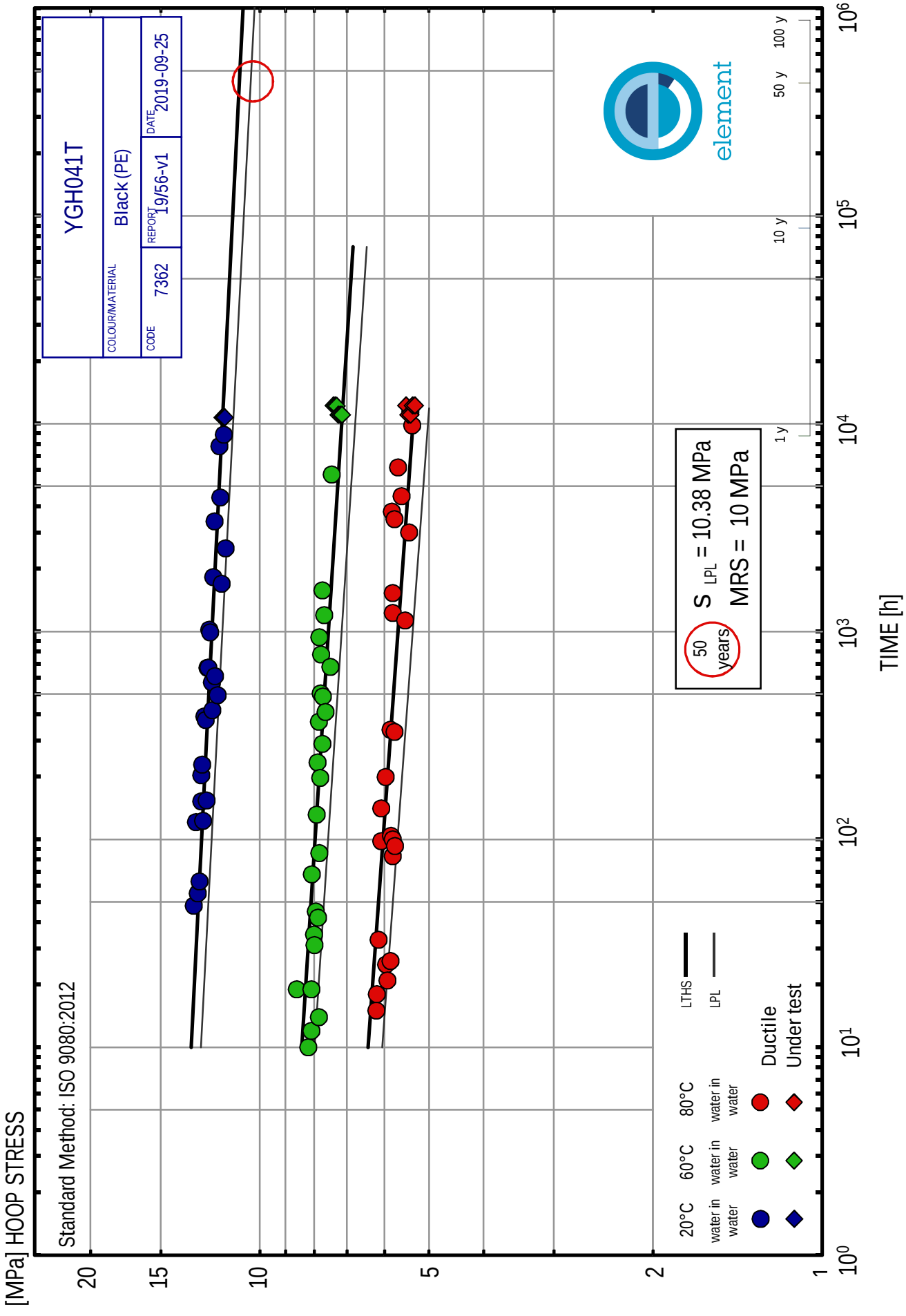
HYDROSTATIC PRESSURE TESTING

Code	T	Start date	Reg date	d_{em}	e_{min}	p	**s**	Burst time	Burst mode	Test time	Remark
	[°C]	[yymmdd]	[yymmdd]	[mm]	[mm]	[bar]	[MPa]	[h]		[h]	
7362-52	80	180416	180416	32.32	3.12	14.32	6.70	0.6	Ductile		
7362-8	80	180416	180416	32.31	3.16	14.32	6.60	1.0	Ductile		
7362-91	80	180416	180417	32.24	3.09	13.83	6.52	8.1	Ductile		
7362-64	80	180416	180417	32.28	3.02	13.24	6.41	2.5	Ductile		
7362-77	80	180416	180417	32.31	3.12	13.44	6.29	5.5	Ductile		
7362-123	80	190108	190109	32.39	3.08	13.04	6.21	15	Ductile		
7362-99	80	180416	180417	32.32	3.16	13.44	6.20	18	Ductile		
7362-152	80	190108	190110	32.32	3.14	13.24	6.15	33	Ductile		
7362-95	80	180416	180423	32.32	3.17	13.24	6.09	98	Ductile		
7362-46	80	190108	190114	32.27	3.12	13.04	6.09	141	Ductile		
7362-116	80	190108	190109	32.42	3.12	12.85	6.03	6.4	Ductile		
7362-90	80	190108	190117	32.29	3.13	12.85	5.98	200	Ductile		
7362-9	80	180416	180417	32.43	3.13	12.75	5.97	25	Ductile		
7362-20	80	180416	180417	32.41	3.10	12.55	5.93	21	Ductile		
7362-179	80	190108	190109	32.43	3.11	12.55	5.92	8.0	Ductile		
7362-54	80	190108	190122	32.27	3.12	12.55	5.86	337	Ductile		
7362-142	80	190314	190318	32.45	3.14	12.55	5.86	26	Ductile		
7362-107	80	180503	180508	32.43	3.10	12.36	5.85	104	Ductile		
7362-57	80	190314	190819	32.37	3.19	12.75	5.83	3 781	Ductile		
7362-7	80	190314	190506	32.27	3.19	12.75	5.81	1 230	Ductile		
7362-22	80	190314	190517	32.34	3.20	12.75	5.80	1 537	Ductile		
7362-59	80	180503	180508	32.43	3.12	12.36	5.80	100	Ductile		
7362-135	80	190108	190114	32.43	3.12	12.36	5.80	83	Ductile		
7362-2	80	190108	190122	32.41	3.14	12.36	5.76	329	Ductile		
7362-38	80	190314	190806	32.31	3.13	12.36	5.76	3 479	Ductile		
7362-41	80	180503	180507	32.45	3.15	12.36	5.75	93	Ductile		
7362-28	80	180416	190102	32.30	3.17	12.36	5.68	6 185	Ductile		
7362-175	80	180503	181109	32.34	3.10	11.87	5.60	4 496	Ductile		
7362-69	80	180416	180604	32.44	3.15	11.87	5.52	1 130	Ductile		
7362-37	80	180503		32.26	3.12	11.77	5.50	->		*>12 234*	
7362-89	80	180620		32.42	3.11	11.57	5.45	->		*>11 082*	
7362-144	80	180620	181023	32.42	3.12	11.57	5.43	2 999	Ductile		

HYDROSTATIC PRESSURE TESTING

Code	T [°C]	Start date [yymmdd]	Reg date [yymmdd]	d_{em} [mm]	e_{min} [mm]	p [bar]	**s** [MPa]	Burst time [h]	Burst mode	Test time [h]	Remark
7362-102	80	180503	190826	32.42	3.09	11.38	5.40	11 510	Ductile		
7362-119	80	180620		32.41	3.09	11.38	5.40	->		*>11 082*	
7362-110	80	180620	190805	32.41	3.11	11.38	5.36	9 851	Ductile		
7362-171	80	180503		32.35	3.11	11.38	5.35	->		*>12 234*	
7362-118	80	180503		32.41	3.09	11.18	5.30	->		*>12 234*	
7362-82	80	180620		32.39	3.01	10.79	5.26	->		*>11 082*	
7362-6	80	180620		32.34	3.21	11.57	5.25	->		*>11 082*	
7362-25	80	180503		32.34	3.19	11.38	5.20	->		*>12 234*	
7362-103	80	180620		32.41	3.10	10.79	5.10	->		*>11 082*	


YGH041T
COLOUR (MATERIAL)
Black (PE)
CODE
7362
DATE
2019-09-25
element
[MPa] HOOP STRESS
Standard Method: ISO 1167:2006
TIME [h]
1 y
10 y
50 y
100 y
20°C water in water
60°C water in water
80°C water in water
Ductile
Under test


YGH041T
COLOUR/MATERIAL Black (PE)
CODE 7362
REPORT 19/56-v1
DATE 2019-09-25
element
[MPa] HOOP STRESS
Standard Method: ISO 9080:2012
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
S LPL = 10.38 MPa
MRS = 10 MPa
50 years
LTHS
LPL
20°C water in water
60°C water in water
80°C water in water
Ductile
Under test

ELEMENT TEST REPORT P-18/156-v1

RAPID CRACK PROPAGATION – CRITICAL PRESSURE

Determination of resistance to rapid crack propagation (RCP) according to ISO 13477 (S4-test) of the black PE pipe grade YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.

SWEDAC ACKREDITERING
Accred. No. 0067
Testing
ISO/IEC 17025

TEST REPORT ISSUED BY AN ACCREDITED TESTING LABORATORY

RESTRICTED DISTRIBUTION

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ELEMENT/P-18/156-v1

2018-11-08

P-11056

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RAPID CRACK PROPAGATION – CRITICAL PRESSURE
Determination of resistance to rapid crack propagation (RCP) according to ISO 13477 (S4-test) of the black PE pipe grade YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.

An evaluation of the critical pressure to rapid crack propagation according to ISO 13477[1] of the PE pipe grade YGH041T black has been performed on behalf of SINOPEC Shanghai Petrochemical Co., Ltd.

Four pipe samples were tested at 0°C at different pressures in accordance with ISO 13477. A summary of the results is presented below.

PIPE GRADE	ELEMENT CODE	DIMENSION	CRITICAL PRESSURE p_{cs4} AT 0°C
YGH041T	7360	250 mm (SDR 11)	10 bar

The results are only valid for the material tested with Element code 7360.

[1] ISO 13477:2008- Thermoplastics pipes for the conveyance of fluids — Determination of resistance to rapid crack propagation (RCP) — Small-scale steady-state test (S4 test)

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APPENDICES

Written by

Nataliya TAUNLEY
PROJECT MANAGER

Reviewed by

Mattias SVEDBERG
KEY ACCOUNT MANAGER

Approved by

Jarno HASSINEN
SITE MANAGER

1 INVESTIGATED PIPE GRADE

The characteristics and code of the investigated grade is presented in Table 1.

TABLE 1 INVESTIGATED PIPE GRADE

Trade name:	YGH041T
Material:	PE
Colour:	Black
Resin producer:	SINOPEC Shanghai Petrochemical Co., Ltd.
Resin production site:	n/a
Resin lot no:	n/a
Resin production date:	n/a
Pipe producer:	n/a
Pipe production date:	n/a
Pipe production lot no:	n/a
Pipe dimensions:	250 mm
Pipe marking:	n/a
Consignor:	Shanghai Shenglan Chemical Mechanical and Electrical Equipment Co.,Ltd.
Arrival date at Element:	2018-04-03
Amount of pipes:	8 x 1 820 mm
Element code:	7360

2 EXPERIMENTAL PROCEDURE

All tests have been performed at Element. The pipes were cut into lengths of 1820 mm and conditioned at -2.8 ±1°C in air for at least 16 h. The objective was to determine the critical pressure at 0°C.

$$T_{cond} = 1.12 \times T - 2.8$$

where

T	[°C]	Test temperature
T_{cond}	[°C]	Conditioning temperature

The internal and external medium was air during the test. The crack initiation is applied using a knife attached to a spring loaded striker. The crack initiation followed within 180 ±20 s from when the test specimen was removed from the conditioning chamber. The pipe samples were tested at different pressures and the crack length was measured after each test.

2.1 Uncertainty measurements

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%. Uncertainty is given as better than values.

TABLE 2 UNCERTAINTY MEASUREMENTS

PARAMETER	UNCERTAINTY[2]
Pipe length	±1 mm
Temperature	±1°C
Pressure	±2%
Velocity	±1 m/s
Time	±1 s

[2] The standard uncertainty of measurement has been determined in accordance with EA Publication EA-4/02 and is documented at Element. The given uncertainty is given as "better than" values.

3 RESULTS

In order to have crack propagation the crack length shall be at least 4.7 times the nominal diameter. Shorter crack lengths are defined as crack arrest. However, the crack length needs to be at least 0.7 times the nominal pipe diameter to be considered as a valid crack.

The highest pressure where crack arrest was obtained was at 10 bar. Therefore the PE pipe grade YGH041T has a critical pressure, $p_{c,S4}$, at 0°C of 10 bar.

A total of four pipes have been tested. The results are presented in Appendix B and shown in Appendix C.

4 CALCULATIONS OF THE CRITICAL PRESSURE ACCORDING TO ISO 4437

The following steps show how to calculate the required critical pressure in ISO 4437 when using the S4-test.

$$p_c \geq 1.5 \times MOP \qquad \textit{Equation 1}$$

$$MOP = \frac{MRS \times 20}{C \times (SDR - 1)} \qquad \textit{Equation 2}$$

$$p_c = 3.6 \times p_{cS4} + 2.6\,bar \qquad \textit{Equation 3}^{3}$$

Combining equations 1-3 gives

$$p_{cS4} \geq \left(1.5 \times \frac{MRS \times 20}{C \times (SDR - 1)} - 2.6\,bar\right) \times \frac{1}{3.6} \qquad \textit{Equation 4}$$

where

MOP	[bar]	Maximum Operating Pressure
p_c	[bar]	Critical pressure using the full scale test
p_{cS4}	[bar]	Critical pressure using the Small-scale steady-state test (S4)
MRS	[MPa]	Minimum required strength
SDR	[1]	Standard dimension ratio
C	[1]	Design coefficient

5 ADDITIONAL COMMENTS

No unusual behaviour was observed during the testing.

[3] NOTE Attention is drawn to the fact that the correlation factor may be modified, when revising this Standard, according to the result of work of ISO/TC 138/SC4 "Plastics pipes, fittings and valves for the supply of gaseous fuels"

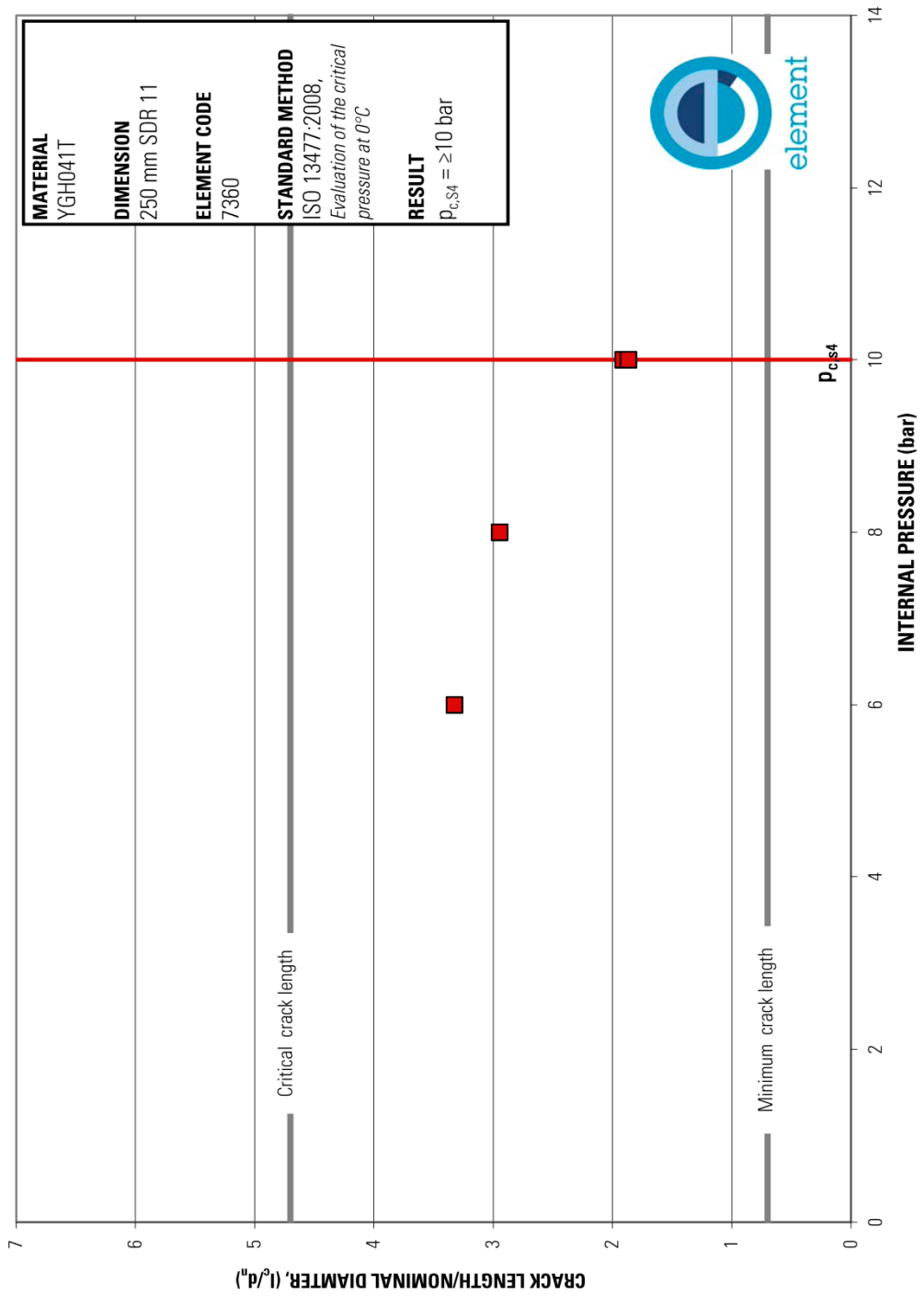
CLIENT INFO	
Client:	SINOPEC Shanghai Petrochemical Co., Ltd.
Department:	Shanghai Shenglan Chemical Mechanical and Electrical Equipment Co.,Ltd.
Street adress:	623Room,6F(s),Jinshan Hotel,No.1 Jinyi Road(E)
Postal code:	Jinshan District, Shanghai
Country:	China
Contact person:	Evan Ding
Phone:	021-57941325
Fax:	021-57941948
E-mail:	evan@nikkiso-sc.com
Web:	www.nikkiso-sc.com

TEST PARAMETERS	
Test laboratory:	Element Materials Technology - Plastic Pipes
Accreditation:	ISO/IEC 17025 Swedac accreditation no. 0067
Test method:	ISO 13477:2008
Test medium (internal/external):	Air/air
Conditioning method (time):	Air refrigerator (24 h)
Nominal pipe diameter, d_n:	250 mm
Pipe series:	SDR 11
Pipe length (total):	1 820 mm
Gauge length:	1 278 mm
Critical crack length:	1 175 mm
Minimum valid crack length:	175 mm
Mass of the striker knife:	0.444 kg
Responsible for the tests:	Niklas Eriksson

TEST RESULTS

SAMPLE[1]	T	DATE	D_{EM}[2]	P[3]	v[4]	CRACK LENGTH[5]	RATIO[6]	
	[°C]	[yymmdd]	[mm]	[bar]	[m/s]	[mm]		
7306-1	0	180904	250.0	6.0	13.50	781	3.32	(crack arrest)
7306-2	0	180905	250.0	8.0	13.62	686	2.94	(crack arrest)
7306-3	0	180913	250.0	10.0	13.48	427	1.91	(crack arrest)
7306-4	0	180914	250.0	10.0	13.62	416	1.86	(crack arrest)

1) Internal reference code at Element
2) Mean outside diameter
3) Internal pressure. Pressures below 2.25 bar have a tolerance more than ±2%
4) Knife speed at impact
5) A valid crack is defined to be 0.7 time the nominal outside diameter
6) If the ratio (crack length/dn) is <4.7 then crack arrest
7) Velocity outside tolerance of 15 ±5 m/s


MATERIAL
YGH041T
DIMENSION
250 mm SDR 11
ELEMENT CODE
7360
STANDARD METHOD
ISO 13477:2008,
Evaluation of the critical pressure at 0°C
RESULT
$p_{c,S4}$ = ≥10 bar
element
$p_{c,S4}$
Critical crack length
Minimum crack length
INTERNAL PRESSURE (bar)
0
2
4
6
8
10
12
14
CRACK LENGTH/NOMINAL DIAMTER, (l_c/d_n)
0
1
2
3
4
5
6
7

ELEMENT/P-18/156-v1

RAPID CRACK PROPAGATION – CRITICAL PRESSURE

Determination of resistance to rapid crack propagation (RCP) according to ISO 13477 (S4-test) of the black PE pipe grade YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.

Mattias SVEDBERG

element

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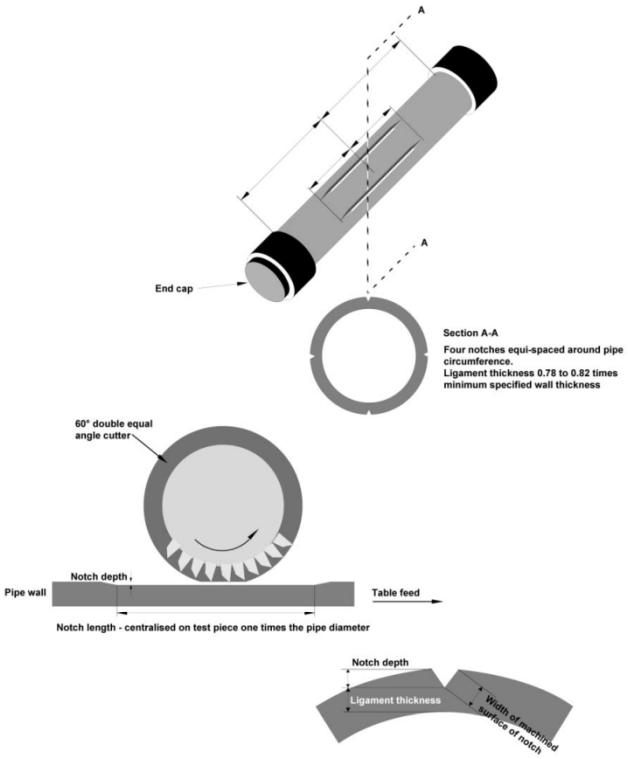
ELEMENT TEST REPORT P-18/157-v1

NOTCH PIPE TESTING

Notch pipe testing according to ISO 13479 of the black PE pipe grade YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.



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ISO/IEC 17025

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ELEMENT P-18/157-v1

2018-11-14

P-11056

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NOTCH PIPE TESTING

Notch pipe testing according to ISO 13479 of the black PE pipe grade YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.

A notch pipe testing program has been performed on behalf of SINOPEC Shanghai Petrochemical Co., Ltd. Three pipe samples of the black PE pipe grade YGH041T were notched and pressure tested according to ISO 13479[1].

The pipe samples were tested at 80°C, using tap water on the inside and on the outside of the pipe specimens.

All the three pipe samples have burst and a summary of the results is presented below.

RESULTS				
PIPE GRADE	ELEMENT CODE	PRESSURE	MINIMUM BURST TIME	LIGAMENT[2]
YGH041T	7361	9.2 bar	1 189 h	OK

The results are only valid for the material tested with Element code 7361.

[1] ISO 13479:2009- Polyolefin pipes for the conveyance of fluids -- Determination of resistance to crack propagation – Test method for slow crack growth on notched pipes (notch test)

[2] The ligament thickness should be 0.78-0.82 times the nominal wall thickness

LIST OF CONTENTS

APPENDICES

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Approved by

Jarno HASSINEN
SITE MANAGER

1 INESTIGATED PIPE GRADE

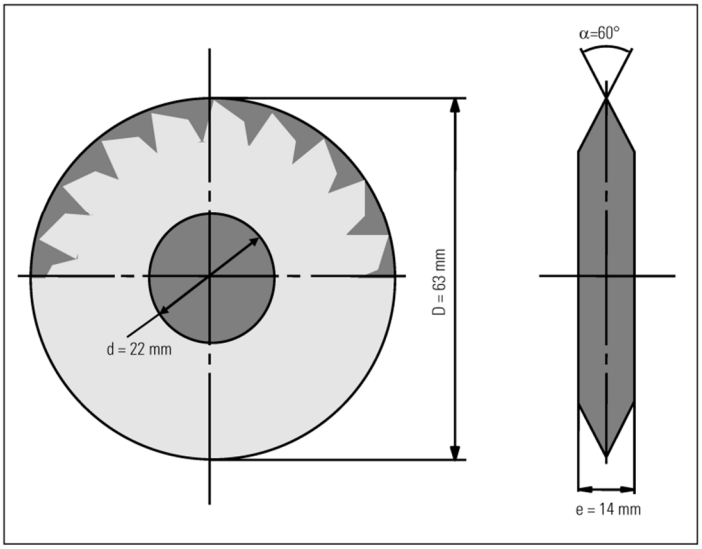
The characteristics and code of the investigated pipe grade is presented below.

INVESTIGATED PIPE GRADE	
Trade name:	YGH041T
Material:	PE
Colour:	Black
Resin producer:	n/a
Pipe producer:	n/a
Pipe production date:	n/a
Lot number:	n/a
Pipe dimension:	110 x 10 mm
SDR:	11
Pipe marking:	No commercial marking
Consignor:	SINOPEC Shanghai Petrochemi Co.,Ltd.
Arrival date at Element:	2018-04-03
Amount of pipes:	12 x 1.0 m
Element code:	7361

2 EXPERIMENTAL PROCEDURE

All tests have been performed at Element. The pipes were notched according to ISO 13479. The cutter is a V-cutter conforming to ISO 6108, for dimensions see Figure 1 below.

Figure 1 *Dimensions for the V-cutter, Double equal angle cutters with plain bore and key drive*



The notch cutter has 20 teeth and is rotating at 760 rpm[3], traversed, at speed of 159 mm/min[3] giving a cutting rate of 0.010 (mm/rev)/tooth accurate within ±0.002 (mm/rev)/tooth. The accuracy of the notch length[3] is better than ±1 mm and the measurement of the ligament thickness[3] is accurate within ±0.1 mm.

The pressure testing is carried out with water filled pipes, the outer environment being water at 80°C. The water used is tap water. The pipes were fitted with brass fittings. The accuracy for the temperature[3] and the pressure[3] are better than ±1°C and +2/-1%, respectively. The measurements of the wall thickness[3] are accurate within ±0.02 mm and the diameters[3] within ±0.1 mm.

The general testing conditions follow ISO 1167:2006.

[3] 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-4/02 and is documented at Element.

3 RESULT

All the three pipe samples have burst and a summary of the results is presented below. Detailed results are presented in Appendix A and B.

RESULTS				
PIPE GRADE	ELEMENT CODE	PRESSURE	MINIMUM BURST TIME	LIGAMENT[4]
YGH041T	7361	9.2 bar	1 189 h	OK

The results are only valid for the material with Element code 7361.

4 ADDITIONAL COMMENTS

No unusual behaviour was observed during the hydrostatic pressure testing.

[4] The ligament thickness should be 0.78-0.82 times the nominal wall thickness

Table A.1 *Notch pipe testing at 80°C using tap water as the internal and external medium.*

Name of the laboratory:	Element Materials Technology - Plastic Pipes, ISO/IEC 17025 Swedac accreditation no. 0067
Pipe grade:	YGH041T
Test method:	ISO 13479:2009
Nominal dimension:	110 x 10 mm (SDR 11)
Pipe length (total/free):	570/430 mm
Fittings:	Wipex brass fittings (Type A)
Internal medium/External medium:	Tap water/Tap water
Conditioning time:	24 h
Responsible for the testing:	Christer Nilsson

CODE[1]	T [°C]	START DATE[2] [yymmdd]	REG DATE[3] [yymmdd]	D_{em}[4] [mm]	P[5] [bar]	TEST TIME [h]	BURST MODE	REMARKS
7361-1	80	2018-04-12	2018-06-07	110.60	9.2	1 303	Mixed	
7361-2	80	2018-04-12	2018-06-04	110.60	9.2	1 219	Mixed	
7361-3	80	2018-04-12	2018-06-01	110.60	9.2	1 189	Mixed	

1) *Internal reference code at Element*
2) *Date when the test began*
3) *Registration date for when the sample burst or was stopped*
4) *Mean outside diameter*
5) *Internal pressure*

Table B.1 *Results from the measurements of the ligament thickness*

CODE	MEASURED NOTCH DEPTH [mm]	RELATIVE NOTCH DEPTH[5] [%]	LIGAMENT THICKNESS [mm]
7361-1			
Notch 1	2.86	26	8.04
Notch 2	2.75	25	8.10
Notch 3	2.87	26	8.05
Notch 4	2.90	26	8.09
7361-2			
Notch 1	2.42	23	8.14
Notch 2	2.47	23	8.08
Notch 3	2.50	24	8.09
Notch 4	2.44	23	8.13
7361-3			
Notch 1	2.67	25	8.03
Notch 2	2.61	24	8.11
Notch 3	2.76	26	8.05
Notch 4	2.64	25	8.05

NOTES

- The bold text indicates in which notch the burst occurred.
- The ligament thickness should be within 7.8 and 8.2 mm for a 110 x 10 mm pipe. The given value refers to the ligament thickness at the notch.
- Complete documentation of the notch measurements is stored at Element.

[5] $\text{Relative notch depth} = \frac{\text{notch depth}}{\text{wall thickness}}$

ELEMENT P-18/157-v1

NOTCH PIPE TESTING

Notch pipe testing according to ISO 13479 of the black PE pipe grade YGH041Tfrom SINOPEC Shanghai Petrochemical Co., Ltd.

Mattias SVEDBERG

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REPORT

issued by an Accredited Testing Laboratory

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Date	Reference	Page
2018-06-25	8F010588	1 (6)

Testing

Exova AB
Box 613
611 10 Nyköping

Testing of PE-material and butt-fusion joints according to ISO 4437-1:2014

Test object
Black polyethylene granules and black polyethylene pipes.

Delivery date
2018-04-16

The delivered pipes and material had the following marking:

Black granules:	Labeled: 7363
Ø 32 mm SDR 11	Labeled: 7362
Ø 110 mm SDR 11	Labeled: 7361

Tests
The following tests were performed on the granules:

Clause according to ISO 4437-1	Characteristic	Method
6.2.3.1, table 1	Compound density	EN ISO 1183
6.2.3.1, table 1	Carbon black content	ISO 6964
6.2.3.1, table 1	Carbon black dispersion	ISO 18553
6.2.3.1, table 1	Volatile content	EN 12099
6.2.3.1, table 1	Oxidation induction time	ISO 11357-6
6.2.3.1, table 1	Melt mass-flow rate	EN ISO 1133

The following tests were performed on the pipes:

Clause according to ISO 4437-1	Characteristic	Method
6.2.3.2, table 2	Resistance to gas condensate	ISO 1167
6.3, table 3	Tensile strength for butt-fusion	ISO 13953

The welding were performed by RISE using the parameters specified in Annex A and B of ISO 11414:2009, normal conditions.

RISE Research Institutes of Sweden AB

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REPORT

Date 2018-06-25 Reference 8F010588 Page 2 (6)

TEST RESULTS

Measurement uncertainty

Reported uncertainty corresponds to an approximate 95 % confidence interval around the measured value. The interval has been calculated in accordance with EA-4/16 (EA guidelines on the expression of uncertainty in quantitative testing), which is normally accomplished by quadratic addition of the actual standard uncertainties and multiplication of the resulting combined standard uncertainty by the coverage factor k=2. The results apply only to the tested objects.

Compound density

Test object	Sample no	Measured value kg/m^3
Granules, 7363	1	959.8
	2	959.8
	3	959.7
	Average	959.8

Test method: *ISO 1183-2:2004*
Sample preparation: *Melt mass-flow rate extrudate*
Immersion liquid: *Isopropanol/water*
Test temperature: *23 ± 0.1 °C*
Date of test: *2018-05-14*

Carbon black content

Test object	Sample no	Measured carbon black %
Granules, 7363	1	2.16
	2	2.15
	3	2.14
	Average	2.1

Test method: *ISO 6964:1986*
Testing temperature: *550 ± 50 °C*
Calcination temperature: *900 ± 50 °C*
Weighing uncertainty *± 0.1 mg*
Date of test: *2018-05-14*

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Carbon black dispersion

Test object	Sample no	Agglomerate grading	Rating of appearance
Granules, 7363	1	3.0	A2
	2	3.0	A2
	3	5.0	A2
	4	3.0	A2
	5	4.5	A2
	6	2.0	A2
	Average	3.4	

Test method: *ISO 18553:2002*
Film preparation method: *Compression method*
Film thickness: *20 ± 10 µm*
Date of test: *2018-05-29*

Volatile content

Dimension	Test No	Measured value mg/kg
Granules, 7363	1	148
	2	152
	Average	150

Test method: *EN 12099:1997*
Drying temperature *105 ± 2 °C*
Weighting uncertainty *0.1 mg*
Date of test: *2018-05-14*

Oxidation induction time

Test no	Mass test sample mg	Measured induction time minutes
Granules, 7363		
1	14.1	95.0
2	13.4	93.8
3	13.6	94.7
Average		95

Test method: *EN ISO 11357-6:2013*
Test equipment: *Mettler Toledo DSC 823^e*
Measurement technique: *Tangent method*
Test temperature: *200 ± 0.2 °C*
Gas flow: *Oxygen: 50 ± 5 ml/minute, Nitrogen 50 ± 5 ml/minute*
The uncertainty in the oxidation induction time is <5 % of the measured value.
Date of test: *2018-05-25*

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Melt mass-flow rate

Test no	Measured melt mass-flow rate g/10 minutes
Granules, 7363	
1	0.31
2	0.32
3	0.32
4	0.32
5	0.32
6	0.32
7	0.32
8	0.32
9	0.32
10	0.32
Average	0.32

Test method: *EN ISO 1133-1:2011*
Test temperature: *190 ± 0.5 °C*
Load: *5000 g ± 0.1 %*
Die: *Length: 8.000 ± 0.025 mm, Bore diameter: 2.095 ± 0.005 mm*
Procedure: *B, displacement-measurement method*
Melt density [g/cm^3]: *0,7636*
Pre-heat time: *Automatic*
The calculated uncertainty at determination of melt mass-flow rate is <5 % of measured value
Date of test: *2018-05-08*

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Tensile strength, butt fused joint

Test no	Maximal tensile strength MPa	Type of failure
Ø 110 mm SDR 11, 7361, #1		
1	25.5	Ductile
2	25.7	Ductile
3	25.5	Ductile
4	25.4	Ductile
Average	25.6	
Ø 110 mm SDR 11, 7361, #2		
1	25.1	Ductile
2	25.1	Ductile
3	25.3	Ductile
4	25.3	Ductile
Average	25.2	
Ø 110 mm SDR 11, 7361, #3		
1	25.6	Ductile
2	25.3	Ductile
3	25.5	Ductile
4	26.2	Ductile
Average	25.7	

Testing method *ISO 13953:2001*
Test temperature: *23 ± 2 °C*
The total calculated uncertainty is <2 %.
Type of test piece: *Type A according to ISO 13953:2001*
Crosshead speed: *5 mm/minute*
Date of test *2018-05-22*

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Ø 32 mm SDR 11 pipes

The pipes were filled with a synthetic natural gas condensate, a mixture of N-decane and 1-3-5-trimethylbenzene in a weight ratio 1:1 for 1500 hours (2018-04-17 –06-18) at +23°C. Immediately after the soaking, the pipes were tested with internal pressure in water at +80°C with the synthetic condensate inside.

Hydrostatic strength

Test no	Mean outside diameter mm	Minimum wall thickness mm	Hoop stress MPa	Test temp. °C	Test pressure MPa	Time to rupture h
Ø 32 mm SDR 11, 7362						
1	32.3	3.10	2.0	80	0.425	>20
2	32.3	3.10	2.0	80	0.425	>20
3	32.3	3.10	2.0	80	0.425	>20

The tests have been interrupted without any failures.

Pressure test method: *EN ISO 1167-1:2006, End caps of type A*
Dimension measurement method: *EN ISO 3126:2005*
The test conditions parameters were:
Free length between the end caps: *400 mm*
Conditioning time: *1 h*
Internal/External medium: *Gas condensate/water*
Time to achieve the pressure: *<5 minutes*
Test temperature: *± 0.3 °C*
Test pressure: *± 0.7 %*
Date of test: *2018-16-18 –06-19*

RISE Research Institutes of Sweden AB
Energy and circular economy - Pipe Centre

Performed by

Signed by: Kristian Thörnblom
Reason: I am the author of this document
Date & Time: 2018-06-25 14:32:57 +02:00

Kristian Thörnblom

Examined by

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REPORT

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Date	Reference	Page
2019-11-15	9F030163	1 (2)

SP Testing

Element Materials Technology
Studsvik 3
611 10 Nyköping

Determination of carbon black dispersion according to ISO18553:2002

Test object
Black polyethylene granules

Delivery date
2019-10-24

Marking
One bag of PE granules with the following marking was sent to RISE by the client:

Marking:
7363

Tests
The following tests was performed:

Characteristic	Method
Carbon black dispersion	ISO 18553:2002

RISE Research Institutes of Sweden AB

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REPORT

Date 2019-11-15 Reference 9F030163 Page 2 (2)

TEST RESULTS

Measurement uncertainty

Reported uncertainty corresponds to an approximate 95 % confidence interval around the measured value. The interval has been calculated in accordance with EA-4/16 (EA guidelines on the expression of uncertainty in quantitative testing), which is normally accomplished by quadratic addition of the actual standard uncertainties and multiplication of the resulting combined standard uncertainty by the coverage factor k=2. For comparisons between test results and possible requirement levels, the following decision rule (according to ISO 17025:2018 7.8.6) has been applied. Measured values are evaluated without regard to measurement uncertainty. The results apply only to the tested objects.

Carbon black dispersion

Sample no	Agglomerate grading	Decisive size group µm	Appearance
Granules			
1	2.0	5-10	A2
2	2.5	5-10	A2
3	2.0	5-10	A2
4	1.5	5-10	A2
5	2.0	5-10	A2
6	2.5	31-40	A2
Average	2.1		

Test method: *ISO 18553:2002*
Film preparation method: *Microtome*
Film thickness: *20 ± 10 µm*
Date of test: *2019-11-15*

RISE Research Institutes of Sweden AB
Energy and circular economy - Pipe Centre

Performed by

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ELEMENT/P-19/56-v1

DETERMINATION OF THE LONG-TERM HYDROSTATIC STRENGTH
ISO 9080:2012-evaluation of the black PE pipe grade YGH041T from SINOPEC Shanghai Petrochemical Co., Ltd.

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