

Test report no.: 223750

Client: ETHYDCO
 Egyptian Ethylene and Derivatives Company
 KM36 Alexandria-Cairo Desert Road
 Alnahda - Amreya - Alexandria,
 Post Office Mubarak Housing, M.B 44,
 Zip Code: 23641, Alex,
 EGYPT

Order: Hydrostatic pressure tests at 20 °C, 60 °C and 80 °C, for the determination of the long-term hydrostatic strength according to DIN EN ISO 9080, on black coloured extruded pipes made of polyethylene (PE) and MRS classification acc. to DIN EN ISO 12612

Production plant: ETHYDCO
 Brand name: black PE 80/ ADVANCENE EEB 4916 AAH
 Material: PE 80

Letter of: 2022-09-13

Reference:

Receipt of samples: 2023-09-25

Sampling:

Test period: 2023-09-26 to 2025-02-20

This test report comprises 14 pages.

Würzburg, 21 February 2025
 Bar/we

i. V. 

Dr.-Ing. Marcus Heindl
 Head of Testing Laboratory



i. A. 

Dipl.-Ing. Tobias Bauer
 Project Manager Pipe Systems

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1 Order

By letter of 2022-09-13 the Egyptian Ethylene and Derivatives Company, placed an order with SKZ – Testing GmbH to carry out hydrostatic pressure tests at 20 °C, 60 °C and 80 °C, for the determination of the long-term hydrostatic strength according to DIN EN ISO 9080, on black coloured extruded pipes made of polyethylene (PE) and MRS classification acc. to DIN EN ISO 12612.

2 Test material

SKZ – Testing GmbH had no influence on the selection of samples and received the following test material from the client.

Sample no.	Designation	DN/OD [mm]	Wall thickness [mm]	Colour	Quantity	Marking
1	Pipe made of PE 80, black coloured, made of black PE 80/ ADVANCENE EEB 4916 AAH	32	3.0	black	240 x 0.5 m	Handwritten: Sample B

3 Test procedure

Usually, we carry out tests according to standards for which we have an accreditation. The list of all standards for which we are accredited can be viewed as an annex to the accreditation certificate on the homepage at <https://www.skz.de/en/testing/products>. In case of non-accredited procedures, they are marked with *. If it is only a matter of deviating test conditions of an accredited standard, this is marked with #.

In case that a conformity assessment is issued, the general decision rule is as follows: The measurement uncertainty and the standard deviation are not taken into account. Deviations from this rule are only made at the client's request, in the case of standard specifications or other specifications about which the client is informed in each individual case.

Unless otherwise noted all tests were carried out at standard atmosphere 23/50, according to DIN EN ISO 291:2008-08 "Plastics – Standard atmospheres for conditioning and testing", class 2.

The tests were carried out according to DIN EN ISO 9080:2013-02, MRS classification according to DIN EN ISO 12612:2010-04

The following tests were carried out:

Section	Test	Requirements acc. to	Test and conditioning of samples acc. to
4.1	Appearance	---	---
4.4 – 4.6	Geometrical characteristics	---	DIN EN ISO 3126:2005-05
4.4 – 4.6	Long-term hydrostatic pressure tests	DIN EN ISO 9080:2013-02	DIN EN ISO 1167-1:2006-05 DIN EN ISO 1167-2:2006-05

Evaluation of test results	Standard / Software
Determination of long-term hydrostatic strength	DIN EN ISO 9080:2013-02 Standard-Extrapolation-Method carried out with Pipeson Analyzer Version 3.9.0 of PIPESON AB
MRS classification	DIN EN ISO 12612:2010-04

Following remarks are used in the test result tables in par. 4.4, 4.5 and 4.6:

- ¹⁾ Time to failure < 10 h. This data point is discarded from extrapolation, acc. to EN ISO 9080:2012, par. 4.2.2.
- ²⁾ This data point is discarded from extrapolation, acc. to EN ISO 9080:2012, par. 4.2.3.
- ³⁾ This data point is discarded from extrapolation, acc. to EN ISO 9080:2012, par. 4.2.4.
- ⁴⁾ This data point is used for extrapolation, acc. to EN ISO 9080:2012, par. 4.2.4.
- ⁵⁾ Failure close to end-cap. This data point is discarded from extrapolation, acc. to EN ISO 1167:2006, par. 10.4.
- ⁶⁾ Technical problem with test equipment. This data point is discarded from extrapolation.

4 Test results

4.1 Surface of the pipe samples

The inside and outside surfaces of the extruded pipe samples did not have any bubbles, voids or other defects on surfaces. The material did not show any visible dirt particles. Samples were coloured black.

4.2 Test temperatures and test medium

Test temperature [°C]	Outside test medium	Pressure medium inside pipes
20	water	water
60	water	water
80	water	water

4.3 Distribution of internal pressure levels and time ranges

Test temp. [°C]	Number of running test pieces	Total number of observations [min. 30]	Distribution of observations		Number of discarded results
			number of observations > 7.000 h [4] ¹⁾	number of observations > 9.000 h [1] ¹⁾	
20	0	31	6	4	25
60	0	35	6	5	19
80	0	30	4	1	17

4.4 Results of long-term internal pressure tests at 20 °C

Sample no.	Test temp. T_t [°C]	Outside diameter d_{em} [mm]	Wall thickness e_{min} [mm]	Test pressure p [bar]	Test stress σ [MPa]	Test duration [h]	Status	Data type	SEM
1	20	32.3	3.1	28.0	13.2	3.1	Ductile	A	No ¹⁾
2	20	32.3	3.1	27.6	13	3.6	Ductile	A	No ¹⁾
3	20	32.3	3.1	26.5	12.5	6.1	Ductile	A	No ¹⁾
4	20	32.3	3.1	26.5	12.5	6.8	Ductile	A	No ¹⁾
5	20	32.3	3.1	26.5	12.5	12.6	Ductile	A	No ²⁾
6	20	32.3	3.1	25.5	12	14.7	Ductile	A	No ²⁾
7	20	32.3	3.1	25.5	12	17.8	Ductile	A	No ²⁾
8	20	32.3	3.1	25.5	12	18.4	Ductile	A	No ²⁾
9	20	32.3	3.1	25.1	11.8	32.4	Ductile	A	No ²⁾
10	20	32.3	3.1	25.1	11.8	41.3	Ductile	A	No ²⁾
11	20	32.3	3.1	25.1	11.8	58.4	Ductile	A	No ²⁾
12	20	32.3	3.1	24.6	11.6	50.5	Ductile	A	No ²⁾
13	20	32.3	3.1	24.6	11.6	81.8	Ductile	A	No ²⁾
14	20	32.3	3.1	24.6	11.6	102.7	Ductile	A	No ²⁾
15	20	32.3	3.1	24.4	11.5	42.4	Ductile	A	No ²⁾
16	20	32.3	3.1	24.4	11.5	46.5	Ductile	A	No ²⁾
17	20	32.3	3.1	24.4	11.5	60.4	Ductile	A	No ²⁾
18	20	32.3	3.1	24.2	11.4	53.1	Ductile	A	No ²⁾
19	20	32.3	3.1	24.2	11.4	68.4	Ductile	A	No ²⁾
20	20	32.3	3.1	24.2	11.4	68.9	Ductile	A	No ²⁾
21	20	32.3	3.1	24.2	11.4	107.2	Ductile	A	Yes
22	20	32.3	3.1	24.1	11.4	130.0	Ductile	A	Yes
23	20	32.3	3.1	24.2	11.4	156.4	Ductile	A	Yes
24	20	32.3	3.1	23.8	11.2	106.7	Ductile	A	Yes
25	20	32.3	3.1	23.8	11.2	110.4	Ductile	A	Yes
26	20	32.3	3.1	23.8	11.2	141.4	Ductile	A	Yes
27	20	32.3	3.1	23.4	11	119.1	Ductile	A	Yes
28	20	32.3	3.1	23.4	11	136.5	Ductile	A	Yes
29	20	32.3	3.1	23.4	11	157.6	Ductile	A	Yes
30	20	32.3	3.1	22.9	10.8	225.7	Ductile	A	Yes

Sample no.	Test temp. Tt [°C]	Outside diameter dem [mm]	Wall thickness emin [mm]	Test pressure p [bar]	Test stress σ [MPa]	Test duration [h]	Status	Data type	SEM
31	20	32.3	3.1	22.9	10.8	262.6	Ductile	A	Yes
32	20	32.3	3.1	22.9	10.8	563.6	Ductile	A	Yes
33	20	32.3	3.1	22.72	10.7	992.6	Ductile	A	Yes
34	20	32.3	3.1	22.72	10.7	1,374.5	Ductile	A	Yes
35	20	32.3	3.1	22.72	10.7	1.478	Ductile	A	Yes
36	20	32.3	3.1	22.5	10.6	434.6	Ductile	A	Yes
37	20	32.3	3.1	22.5	10.6	546.8	Ductile	A	Yes
38	20	32.3	3.1	22.5	10.6	1,319.1	Ductile	A	Yes
39	20	32.3	3.1	22.08	10.4	1,452.6	Ductile	A	Yes
40	20	32.3	3.1	22.08	10.4	1,622.8	Ductile	A	Yes
41	20	32.3	3.1	22.08	10.4	5,093.5	Ductile	A	Yes
42	20	32.3	3.1	21.9	10.3	2,438.6	Ductile	A	Yes
43	20	32.3	3.1	21.9	10.3	5,260.3	Ductile	A	Yes
44	20	32.3	3.1	21.9	10.3	5,570.4	Ductile	A	Yes
45	20	32.3	3.1	21.66	10.2	4,211.7	Ductile	A	Yes
46	20	32.3	3.1	21.66	10.2	7,072.5	Stopped	A	Yes ⁴⁾
47	20	32.3	3.1	21.66	10.2	7,072.5	Stopped	A	Yes ⁴⁾
48	20	32.3	3.1	21.2	10	10,046.9	Stopped	A	Yes ⁴⁾
49	20	32.3	3.1	21.2	10	10,046.9	Stopped	A	Yes ⁴⁾
50	20	32.3	3.1	21.2	10	10,046.9	Stopped	A	Yes ⁴⁾
51	20	32.3	3.1	20.8	9.8	10,075.4	Stopped	A	Yes ⁴⁾
52	20	32.3	3.1	20.8	9.8	10,075.4	Stopped	A	No ^{3)v}
53	20	32.3	3.1	20.8	9.8	10,075.4	Stopped	A	No ³⁾
54	20	32.3	3.1	20.4	9.6	9,904.3	Stopped	A	No ³⁾
55	20	32.3	3.1	20.4	9.6	9,904.3	Stopped	A	No ³⁾
56	20	32.3	3.1	20.4	9.6	9,904.3	Stopped	A	No ³⁾

4.5 Results of long-term internal pressure tests at 60 °C

Sample no.	Test temp. Tt [°C]	Outside diameter dem [mm]	Wall thickness emin [mm]	Test pressure p [bar]	Test stress σ [MPa]	Test duration [h]	Status	Data type	SEM
101	60	32.3	3.1	15.5	7.3	0.3	Ductile	A	No ¹⁾
102	60	32.3	3.1	15.1	7.1	1.4	Ductile	A	No ¹⁾
103	60	32.3	3.1	14.4	6.8	9.5	Ductile	A	No ¹⁾
104	60	32.3	3.1	14.2	6.7	8.5	Ductile	A	No ¹⁾
105	60	32.3	3.1	14.2	6.7	40.8	Ductile	A	Yes
106	60	32.3	3.1	14.2	6.7	54.8	Ductile	A	Yes
107	60	32.3	3.1	14.16	6.67	42.5	Ductile	A	Yes
108	60	32.3	3.1	14.16	6.67	70.3	Ductile	A	Yes
109	60	32.3	3.1	14.16	6.67	139.0	Ductile	A	Yes
110	60	32.3	3.1	14.12	6.65	27.5	Ductile	A	Yes
111	60	32.3	3.1	14.12	6.65	75.5	Ductile	A	Yes
112	60	32.3	3.1	14.12	6.65	83.0	Ductile	A	Yes
113	60	32.3	3.1	14.1	6.64	32.9	Ductile	A	Yes
114	60	32.3	3.1	14.1	6.64	42.2	Ductile	A	Yes
115	60	32.3	3.1	14.1	6.64	76.5	Ductile	A	Yes
116	60	32.3	3.1	14	6.6	51.3	Ductile	A	Yes
117	60	32.3	3.1	14	6.6	55.8	Ductile	A	Yes
118	60	32.3	3.1	14	6.6	125.8	Ductile	A	Yes
119	60	32.3	3.1	13.95	6.57	86.4	Ductile	A	Yes
120	60	32.3	3.1	13.95	6.57	113.3	Ductile	A	Yes
121	60	32.3	3.1	13.95	6.57	116.4	Ductile	A	Yes
122	60	32.3	3.1	13.9	6.55	83.2	Ductile	A	Yes
123	60	32.3	3.1	13.9	6.55	108.1	Ductile	A	Yes
124	60	32.3	3.1	13.9	6.55	340.7	Ductile	A	Yes
125	60	32.3	3.1	13.8	6.5	408.7	Ductile	A	Yes
126	60	32.3	3.1	13.8	6.5	498.7	Ductile	A	Yes
127	60	32.3	3.1	13.8	6.5	991.1	Ductile	A	Yes
128	60	32.3	3.1	13.7	6.45	301.3	Ductile	A	Yes
129	60	32.3	3.1	13.7	6.45	1,556.2	Ductile	A	Yes
130	60	32.3	3.1	13.7	6.45	1,633.3	Ductile	A	Yes

Sample no.	Test temp. Tt [°C]	Outside diameter dem [mm]	Wall thickness emin [mm]	Test pressure p [bar]	Test stress σ [MPa]	Test duration [h]	Status	Data type	SEM
131	60	32.3	3.1	13.6	6.4	706	Ductile	A	Yes
132	60	32.3	3.1	13.6	6.4	1,239.9	Ductile	A	Yes
133	60	32.3	3.1	13.6	6.4	2,679.1	Ductile	A	Yes
134	60	32.3	3.1	13.4	6.3	7,633.1	Ductile	A	Yes
135	60	32.3	3.1	13.4	6.3	10,915.7	Stopped	A	Yes ⁴⁾
136	60	32.3	3.1	13.4	6.3	10,915.7	Stopped	A	Yes ⁴⁾
137	60	32.3	3.1	13.2	6.2	10,865.0	Stopped	A	Yes ⁴⁾
138	60	32.3	3.1	13.2	6.2	10,865.0	Stopped	A	Yes ⁴⁾
139	60	32.3	3.1	13.2	6.2	10,865	Stopped	A	Yes ⁴⁾
140	60	32.3	3.1	13	6.1	10,095.5	Stopped	A	No ³⁾
141	60	32.3	3.1	13	6.1	10,095.5	Stopped	A	No ³⁾
142	60	32.3	3.1	13	6.1	10,095.5	Stopped	A	No ³⁾
143	60	32.3	3.1	12.7	6	10,013.7	Stopped	A	No ³⁾
144	60	32.3	3.1	12.7	6	10,013.7	Stopped	A	No ³⁾
145	60	32.3	3.1	12.7	6	10,013.7	Stopped	A	No ³⁾
146	60	32.3	3.1	12.5	5.9	10,075.5	Stopped	A	No ³⁾
147	60	32.3	3.1	12.5	5.9	10,075.5	Stopped	A	No ³⁾
148	60	32.3	3.1	12.5	5.9	10,075.5	Stopped	A	No ³⁾
149	60	32.3	3.1	12.32	5.8	4,986.40	Stopped	A	No ³⁾
150	60	32.3	3.1	12.32	5.8	4,986.4	Stopped	A	No ³⁾
151	60	32.3	3.1	12.32	5.8	4,986.4	Stopped	A	No ³⁾
152	60	32.3	3.1	11.89	5.6	4,972.8	Stopped	A	No ³⁾
153	60	32.3	3.1	11.89	5.6	4,972.8	Stopped	A	No ³⁾
154	60	32.3	3.1	11.89	5.6	4,972.8	Stopped	A	No ³⁾

4.6 Results of long-term internal pressure tests at 80 °C

Sample no.	Test temp. Tt [°C]	Outside diameter dem [mm]	Wall thickness emin [mm]	Test pressure p [bar]	Test stress σ [MPa]	Test duration [h]	Status	Data type	SEM
201	80	32.3	3.1	12.1	5.7	0.2	Ductile	A	No ¹⁾
202	80	32.3	3.1	10.6	5	10.6	Ductile	A	Yes
203	80	32.3	3.1	10.5	4.95	30.9	Ductile	A	Yes
204	80	32.3	3.1	10.5	4.95	34.6	Ductile	A	Yes
205	80	32.3	3.1	10.5	4.95	117.9	Ductile	A	Yes
206	80	32.3	3.1	10.4	4.9	20	Ductile	A	Yes
207	80	32.3	3.1	10.4	4.9	83.1	Ductile	A	Yes
208	80	32.3	3.1	10.4	4.9	165.2	Ductile	A	Yes
209	80	32.3	3.1	10.3	4.85	118.7	Ductile	A	Yes
210	80	32.3	3.1	10.3	4.85	134.8	Ductile	A	Yes
211	80	32.3	3.1	10.3	4.85	219.2	Ductile	A	Yes
212	80	32.3	3.1	10.2	4.8	140.7	Ductile	A	Yes
213	80	32.3	3.1	10.2	4.8	196	Ductile	A	Yes
214	80	32.3	3.1	10.2	4.8	263.4	Ductile	A	Yes
215	80	32.3	3.1	10.09	4.75	852.2	Ductile	A	Yes
216	80	32.3	3.1	10.09	4.75	1,085.2	Ductile	A	Yes
217	80	32.3	3.1	10.09	4.75	2,027.9	Stopped	A	Yes ⁴⁾
218	80	32.3	3.1	9.98	4.7	345.5	Ductile	A	Yes
219	80	32.3	3.1	9.98	4.7	771.8	Ductile	A	Yes
220	80	32.3	3.1	9.98	4.7	823.3	Ductile	A	Yes
221	80	32.3	3.1	9.77	4.6	980.5	Ductile	A	Yes
222	80	32.3	3.1	9.77	4.6	6,059.1	Brittle	A	Yes
223	80	32.3	3.1	9.77	4.6	7,240	Brittle	A	Yes
224	80	32.3	3.1	9.66	4.55	3,748.7	Stopped	B	No ⁶⁾
225	80	32.3	3.1	9.66	4.55	3,748.7	Stopped	B	No ⁶⁾
226	80	32.3	3.1	9.66	4.55	3,748.7	Stopped	B	No ⁶⁾
227	80	32.3	3.1	9.55	4.5	2,458.7	Stopped	B	No ⁵⁾
228	80	32.3	3.1	9.55	4.5	3,966.4	Ductile	B	Yes
229	80	32.3	3.1	9.55	4.5	7,076.1	Brittle	B	Yes
230	80	32.3	3.1	9.34	4.4	3,245.8	Ductile	B	Yes

Sample no.	Test temp. Tt [°C]	Outside diameter dem [mm]	Wall thickness emin [mm]	Test pressure p [bar]	Test stress σ [MPa]	Test duration [h]	Status	Data type	SEM
231	80	32,3	3,1	9,34	4,4	5,377.5	Ductile	B	Yes
232	80	32,3	3,1	9,34	4,4	10,001.4	Stopped	B	Yes ⁴⁾
233	80	32,3	3,1	9,13	4,3	4,226.0	Brittle	B	Yes
234	80	32,3	3,1	9,13	4,3	6,265.5	Brittle	B	Yes
235	80	32,3	3,1	9,13	4,3	7,016.6	Stopped	B	Yes ⁴⁾
236	80	32,3	3,1	9,02	4,25	9,087.3	Stopped	B	No ³⁾
237	80	32,3	3,1	9,02	4,25	9,087.3	Stopped	B	No ³⁾
238	80	32,3	3,1	9,02	4,25	9,087.3	Stopped	B	No ³⁾
239	80	32,3	3,1	8,92	4,2	6,800.0	Stopped	B	No ³⁾
240	80	32,3	3,1	8,92	4,2	6,870.6	Stopped	A	No ³⁾
241	80	32,3	3,1	8,92	4,2	6,870.6	Stopped	A	No ³⁾
242	80	32,3	3,1	8,49	4	10,079.5	Stopped	A	No ³⁾
243	80	32,3	3,1	8,49	4	10,079.5	Stopped	A	No ³⁾
244	80	32,3	3,1	8,49	4	10,079.5	Stopped	A	No ³⁾
245	80	32,3	3,1	8,07	3,8	4,971.7	Stopped	A	No ³⁾
246	8	32,3	3,1	8,07	3,8	4,971.7	Stopped	A	No ³⁾ o
247	80	32,3	3,1	8,07	3,8	4,971.7	Stopped	A	No ³⁾

4.7 Use of SEM (Standard-Extrapolation-Method)

With the measuring results represented in paragraphs 5.3.4.1 to 5.3.4.4 a multiple linear regression analysis was executed by means of the SEM-software packages (see item 4). For representation of results the 4-parameter model was selected as the version with the most plausible results. The stress logarithm is calculated with following equation:

$$\log(\sigma) = \frac{\left(\log(t) - C_1 - \frac{C_2}{T} \right)}{\left(C_3 + \frac{C_4}{T} \right)}$$

where

σ	=	Stress. in megapascals [MPa]
t	=	Time to failure. in hours [h]
T	=	Temperature. in Kelvin ($^{\circ}\text{C} + 273.15$)
C_1, C_2, C_3, C_4	=	Regression coefficients used in 4-Parameter-Model

4.8 Results of SEM (Standard-Extrapolation-Method). regression coefficients

Following regression coefficients and added standard deviation were determined executed by means of the SEM-software packages (see item 4):

Regression coefficient	C ₁	C ₂	C ₃	C ₄
Value	-114.582	50,089.373	39.609	-26,831.535
Standard deviation	10,259	4,052.334	7.513	2,955.806

These coefficients are only valid for pipes made of the material stated in paragraph 2.

4.9 Results of SEM (Standard-Extrapolation-Method). extrapolated values of strength

Following values of strength are represented:

σ_{LTHS} = Long-term hydrostatic strength in MPa predicted mean strength at temperature T after time t)

σ_{LPL} = Lower confidence limit of the predicted hydrostatic strength in MPa (the 97.5 % lower confidence limit of the predicted hydrostatic strength at a temperature T and time t. It's given by $\sigma_{LPL} = \sigma_{(T, t, 0.975)}$)

σ_{LTHS} -values [MPa]								
Time [h]	1	10	100	1000	8,760	10,000	100,000	438,000
Temperature [°C]								
20	12.136	11.609	11.106	10.624	10.189	10.163	9.722	9.450
60	7.480	7.071	6.684	6.318	5.992	5.973	5.646 *)	5.446 *)
80	5.615	5.271	4.948	4.644	4.375 *)	4.359 *)	4.092 *)	3.929 *)

σ_{LPL} -values [MPa]. confidence limit. one-sided = 0.975								
Time [h]	1	10	100	1000	8,760	10,000	100,000	438,000
Temperature [°C]								
20	11.645	11.158	10.681	10.213	9.782	9.756	9.309	9.029
60	7.107	6.728	6.362	6.007	5.685	5.665	5.336 *)	5.133 *)
80	5.303	4.983	4.676	4.381	4.115 *)	4.099 *)	3.829 *)	3.664 *)

*) Not covered by extrapolation time factors, acc. to IS 9080.

For 80 °C the evaluation software identified a knee point at 5,134.5 hours. The requirement of ISO 4427-1 and ISO 4437-1 that no knee should be detected at 80 °C below 5,000 hours is met.

5 Results of SEM and MRS-classification according to EN ISO 12162:2009

Based on the available results and following the classification of DIN EN ISO 12162:2010-04 "Thermoplastics materials for pipes and fittings for pressure applications – Classification, designation and design coefficient (ISO 12162:7009)" $\sigma_{LPL} = 9.029$ MPa at 20 °C for **ADVANCENE EEB 4916 AAH** after a time of 50 years is equivalent to **MRS (Minimum required strength) value 8 MPa.**

Thus the material **ADVANCENE EEB 4916 AAH** is designated as PE 80.

6 Graphical presentation of the results

6.1 Graph from Pipeson Analyzer Version 3.9.0 (without excluded data)

