

**Interim test report no.:** 223751-I

**Client:** ETHYDCO  
 Egyptian Ethylene and Derivatives Co.  
 Kilo 36 Alex-Cairo Desert Road  
 El-Nahda Industrial Area, Amreya - Alexandria  
 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 100/ADVANCENE bEEB5906AAH (new additive formulation)  
 Material: PE 100

**Letter of:** 2022-09-13

**Reference:** CONTRACT NO. 3/2022

**Receipt of samples:** 2022-10-06

**Sampling:**


**Test period:** 2022-10-20 to 2023-12-28

This interim test report comprises 14 pages.

Würzburg, 28 December 2023  
 Bar/we

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i. A.   
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## 1 Order

By letter of 2022-09-13 the company ETHYDCO, Egyptian Ethylene and Derivatives Co., Kilo 36 Alex-Cairo Desert Road, El-Nahda Industrial Area, Amreya – Alexandria, EGYPT, 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, black coloured	32	3.0	black	240 x 0.5 m	no marking

### 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 clients'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 cahracteristics	---	DIN EN ISO 3126:2005-05
4.4 – 4.6	Long-term hydrostatic pressure tests	DIN EN ISO 9080:2013-02	DIN EN SIO 1167-1:2006-05 DIN EN SIO 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 <b>Pipeson Analyzer Version 3.2.7</b> of PIPESON AB
MRS classification	DIN EN ISO 12162:2010-04

## 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 observations (time to failure > 10 h)	Number of interrupted test pieces	Number of running test pieces	Total number of observations [30] <sup>1)</sup>	Distribution of observations		Number of discarded results <sup>2)</sup>
					number of observations > 7.000 h [4] <sup>1)</sup>	number of observations > 9.000 h [1] <sup>1)</sup>	
20	27	0	13	27	3	2	37
60	29	0	24	29	9	2	24
80	30	0	9	30	4	0	11

<sup>1)</sup> Values in [ ]: Minimum number of observations according to DIN EN ISO 9080:2013-02, paragraph 4.2.1.

<sup>2)</sup> According to DIN EN ISO 9080:2013-02, paragraphs 4.2.2, 4.2.3 and 4.2.4 discarded failure times.

#### 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 $\sigma$ [MPa]	Test duration [h]	Status	Data type	SEM
1	20	32.2	3.1	32.2	15.1	2.97	Ductile	A	No
2	20	32.2	3	29.8	14.5	7.91	Ductile	A	No
3	20	32.1	3.1	29.6	13.85	13.22	Ductile	A	No
4	20	32.1	3.1	19.6	13.85	9.23	Ductile	A	No
5	20	32.1	3.1	29.6	13.85	10.32	Ductile	A	No
6	20	32.1	3.0	29.3	14.2	7.82	Ductile	A	No
7	20	32.1	3.0	29.3	14.2	17.86	Ductile	A	No
8	20	32.1	3	29.3	14.2	12.85	Ductile	A	No
9	20	32.2	3.1	28.1	13.2	31.25	Ductile	A	No
10	20	32.1	3.1	25.7	12	258.45	Ductile	A	No
11	20	32.1	3.1	25.7	12	422.87	Ductile	A	No
12	20	32.1	3.1	25.7	12	569.22	Ductile	A	No
13	20	32.1	3.1	24.6	11.5	1,698.70	Ductile	A	Yes
14	20	32.1	3.1	24.6	11.5	1,363.70	Ductile	A	Yes
15	20	32.1	3.1	24.6	11.5	5,206.70	Ductile	A	Yes
16	20	32.1	3.1	25.1	11.75	428.58	Ductile	A	No
17	20	32.1	3.1	25.1	11.75	1,447.50	Ductile	A	Yes
18	20	32.1	3.1	25.1	11.75	1,039.60	Ductile	A	Yes
19	20	32.1	3.1	27.8	13	44.97	Ductile	A	No
20	20	32.1	3.1	27.8	13	33.9	Ductile	A	No
21	20	32.1	3.1	27.8	13	56.75	Ductile	A	No
22	20	32.1	3.1	26.7	12.5	169.94	Ductile	A	No
23	20	32.1	3.1	26.7	12.5	64.53	Ductile	A	No
24	20	32.1	3.1	26.7	12.5	87.43	Ductile	A	No
25	20	32.2	3.1	24	11.25	9,350	OnTest	A	Yes
26	20	32.2	3.1	24	11.25	7,859.10	Ductile	A	Yes
27	20	32.2	3.1	24	11.25	9,350	OnTest	A	Yes
28	20	32.2	3.1	23.4	11	9,305	OnTest	A	No
29	20	32.2	3.1	23.4	11	9,305	OnTest	A	No
30	20	32.2	3.1	23.4	11	9,305	OnTest	A	No
31	20	32.2	3.1	27.2	12.75	52.5	Ductile	A	No
32	20	32.2	3.1	27.2	12.75	73.8	Ductile	A	No

Sample no.	Test temp. $T_t$ [°C]	Outside diameter $d_{em}$ [mm]	Wall thickness $e_{min}$ [mm]	Test pressure $p$ [bar]	Test stress $\sigma$ [MPa]	Test duration [h]	Status	Data type	SEM
33	20	32.2	3.1	27.2	12.75	109,0	Ductile	A	No
34	20	32.2	3	25.2	12.25	728.7	Ductile	A	No
35	20	32.1	3.1	25	11.7	1,828.90	OtherFailure	A	Yes
36	20	32.1	3.1	25	11.7	415.8	OtherFailure	A	No
37	20	32.1	3.1	25	11.7	1.585.8	OtherFailure	A	Yes
38	20	32.1	3.1	24.9	11.65	1.020.2	Ductile	A	Yes
39	20	32.1	3.1	24.9	11.65	737.7	Ductile	A	Yes
40	20	32.1	3.1	24.9	11.65	549.7	Ductile	A	No
41	20	32.1	3.1	24.4	11.4	2,184.1	Ductile	A	Yes
42	20	32.1	3.1	24.4	11.4	3,172.8	Ductile	A	Yes
43	20	32.1	3.1	24.4	11.4	6,485	OnTest	A	Yes
44	20	32.1	3.1	24.2	11.3	3,285	OnTest	A	No
45	20	32.1	3.1	24.2	11.3	3,285	OnTest	A	No
46	20	32.1	3.1	24.2	11.3	3,285	OnTest	A	No
47	20	32.1	3.1	24.8	11.6	1,827.90	Ductile	A	Yes
48	20	32.1	3.1	24.8	11.6	1,635.20	Ductile	A	Yes
49	20	32.1	3.1	24.8	11.6	6,440	OnTest	A	Yes
50	20	32.1	3.1	24.5	11.45	1,090	Ductile	A	Yes
51	20	32.1	3.1	24.5	11.45	5,320.6	Ductile	A	Yes
52	20	32.1	3.1	24.5	11.45	5,412.90	Ductile	A	Yes
53	20	32.1	3.1	24.7	11.55	137.6	Ductile	A	No
54	20	32.1	3.1	24.7	11.55	298.3	Ductile	A	No
55	20	32.1	3.1	24.7	11.55	473.2	Ductile	A	No
56	20	32.1	3.1	24.9	11.65	499.4	Ductile	A	No
57	20	32.1	3.1	24.9	11.65	1,371.60	Ductile	A	Yes
58	20	32.1	3.1	24.9	11.65	2,187.50	Ductile	A	Yes
59	20	32.1	3.1	24.7	11.55	1,506	Ductile	A	Yes
60	20	32.1	3.1	24.7	11.55	4,430	OnTest	A	Yes
61	20	32.1	3.1	24.7	11.55	4,430	OnTest	A	Yes
62	20	32.1	3.1	24.3	11.35	3,603.8	Ductile	A	Yes
63	20	32.1	3.1	24.3	11.35	4,200	OnTest	A	No
64	20	32.1	3.1	24.3	11.35	4,200	OnTest	A	No

#### 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 $\sigma$ [MPa]	Test duration [h]	Status	Data type	SEM
100	60	32.2	3.1	18	8.45	0.79	Ductile	A	No
101	60	32.1	3.1	18.1	8.45	0.45	Ductile	A	No
102	60	32.1	3.1	17.7	8.3	1.8	Ductile	A	No
103	60	32.1	3.1	17.3	8.1	5.57	Ductile	A	No
104	60	32.1	3.1	16.9	7.9	30.32	Ductile	A	Yes
105	60	32.1	3.1	17.1	8	117.02	Ductile	A	Yes
106	60	32.1	3.1	17.1	8	18.1	Ductile	A	Yes
107	60	32.1	3.1	17.1	8	5.42	Ductile	A	No
108	60	32.1	3.1	16	7.5	9,770	OnTest	A	Yes
109	60	32.1	3.1	16	7.5	4,026.30	OtherFailure	A	Yes
110	60	32.1	3.1	16	7.5	9,770	OnTest	A	Yes
111	60	32.1	3.1	15.5	7.25	9,830	OnTest	A	No
112	60	32.1	3.1	15.5	7.25	9,830	OnTest	A	No
113	60	32.1	3.1	15.5	7.25	9,830	OnTest	A	No
114	60	32.2	3.1	16.4	7.7	215.81	Ductile	A	Yes
115	60	32.2	3.1	16.4	7.7	817.8	Ductile	A	Yes
116	60	32.2	3.1	16.4	7.7	354.2	Ductile	A	Yes
117	60	32.2	3.1	16.8	7.9	34.93	Ductile	A	Yes
118	60	32.2	3.1	16.8	7.9	53.21	Ductile	A	Yes
119	60	32.2	3.1	16.8	7.9	28.7	Ductile	A	Yes
120	60	32.2	3.0	16	7.8	2,192.50	Ductile	A	Yes
121	60	32.2	3.0	16	7.8	689.2	Ductile	A	Yes
122	60	32.2	3.0	16	7.8	8,870	OnTest	A	Yes
123	60	32.2	3.0	15.2	7.4	8,820	OnTest	A	Yes
124	60	32.2	3.0	15.2	7.4	8,820	OnTest	A	Yes
125	60	32.2	3.0	15.2	7.4	8,763	Brittle	A	Yes
126	60	32.2	3.1	15.1	7.1	8,870	OnTest	A	No
127	60	32.2	3.1	15.1	7.1	8,870	OnTest	A	No
128	60	32.2	3.1	15.1	7.1	8,870	OnTest	A	No
129	60	32.2	3.1	14.9	7	8,860	OnTest	A	No
130	60	32.2	3.1	14.9	7	8,860	OnTest	A	No

Sample no.	Test temp. Tt [°C]	Outside diameter dem [mm]	Wall thickness emin [mm]	Test pressure p [bar]	Test stress $\sigma$ [MPa]	Test duration [h]	Status	Data type	SEM
131	60	32.2	3.1	14.9	7	3,027.80	Ductile	A	No
132	60	32.2	3	15.6	7.6	8,845	OnTest	A	Yes
133	60	32.2	3	15.6	7.6	8,845	OnTest	A	Yes
134	60	32.2	3	15.6	7.6	8,845	OnTest	A	Yes
135	60	32.1	3.1	15.6	7.3	3,468.70	OtherFailure	A	Yes
136	60	32.1	3.1	15.6	7.3	4,387	OnTest	A	No
137	60	32.1	3.1	15.6	7.3	4,387	OnTest	A	No
138	60	32.1	3.1	15.4	7.2	4,440	OnTest	A	No
139	60	32.1	3.1	15.4	7.2	4,440	OnTest	A	No
140	60	32.1	3.1	15.4	7.2	4,440	OnTest	A	No
141	60	32.1	3.1	16.36	7.65	595	OnTest	A	No
142	60	32.1	3.1	16.36	7.65	595	OnTest	A	No
143	60	32.1	3.1	16.36	7.65	595	OnTest	A	No
144	60	32.1	3.1	16.57	7.75	581.9	Ductile	A	Yes
145	60	32.1	3.1	16.57	7.75	806.5	Ductile	A	No
146	60	32.1	3.1	16.57	7.75	96.1	Ductile	A	Yes
147	60	32.1	3.1	17	7.95	32.6	Ductile	A	Yes
148	60	32.1	3.1	17	7.95	6	Ductile	A	No
149	60	32.1	3.1	17	7.95	29.1	Ductile	A	Yes
150	60	32.1	3.1	16.78	7.85	13.7	Ductile	A	Yes
151	60	32.1	3.1	16.78	7.85	44.5	Ductile	A	Yes
152	60	32.1	3.1	16.78	7.85	314.1	Ductile	A	Yes
152	60	32.2	3.1	14.9	7	3,027.80	Ductile	A	No



#### 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 $\sigma$ [MPa]	Test duration [h]	Status	Data type	SEM
200	80	32.1	3.1	13.7	6.4	0.74	Ductile	A	No
201	80	32.1	3.1	14	6.55	0.55	Ductile	A	No
202	80	32.1	3.1	12.8	6	48.22	Ductile	A	Yes
203	80	32.2	3	12.3	6	2,565.8	Brittle	A	Yes
204	80	32.1	3.1	12.2	5.7	6,879.2	Brittle	A	Yes
205	80	32.1	3.1	12.2	5.7	2,800.0	Brittle	A	Yes
206	80	32.1	3.1	12.2	5.7	3,035.97	Brittle	A	Yes
207	80	32.1	3.1	13	6.1	19.39	Ductile	A	Yes
208	80	32.1	3.1	13	6.1	95.5	Ductile	A	Yes
209	80	32.1	3.1	13	6.1	229.39	Ductile	A	Yes
210	80	32.1	3.1	11.8	5.5	4,381.10	Brittle	A	Yes
211	80	32.1	3.1	11.8	5.5	8,367.40	Brittle	A	Yes
212	80	32.1	3.1	11.8	5.5	3,561.90	Brittle	A	Yes
213	80	32.2	3.1	12.4	5.8	2,137.60	OtherFailure	A	Yes
214	80	32.2	3.1	12.4	5.8	3,220.80	Brittle	A	Yes
215	80	32.2	3.1	12.4	5.8	2,650.20	OtherFailure	A	Yes
216	80	32.2	3.1	12.6	5.9	934.51	Ductile	A	Yes
217	80	32.2	3.1	12.6	5.9	1.980	OtherFailure	A	Yes
218	80	32.2	3.1	12.6	5.9	532.17	Ductile	A	Yes
219	80	32.1	3	11.6	5.6	5,363.20	Brittle	A	Yes
220	80	32.1	3	11.6	5.6	4,135.10	Brittle	A	Yes
221	80	32.1	3	11.6	5.6	7,736.90	Brittle	A	Yes
222	80	32.2	3.1	11.7	5.5	3,667.70	Brittle	A	Yes
223	80	32.2	3.1	11.7	5.5	6,481.50	Brittle	A	Yes
224	80	32.2	3.1	11.7	5.5	6,545.80	Brittle	A	Yes
225	80	32.2	3.1	11.5	5.4	4,309.50	Brittle	A	Yes
226	80	32.2	3.1	11.5	5.4	6,325.10	Brittle	A	Yes
227	80	32.2	3.1	11.5	5.4	7,601.10	Brittle	A	Yes
228	80	32.2	3	12.5	6.1	115.8	Ductile	A	Yes
229	80	32.2	3	12.5	6.1	2.304	OtherFailure	A	Yes
230	80	32.2	3	12.5	6.1	1,157.70	OtherFailure	A	Yes

Sample no.	Test temp. Tt [°C]	Outside diameter dem [mm]	Wall thickness emin [mm]	Test pressure p [bar]	Test stress $\sigma$ [MPa]	Test duration [h]	Status	Data type	SEM
231	80	32.2	3	11.8	5.75	5,441.8	Brittle	A	Yes
232	80	32.2	3	11.8	5.75	7,619	Brittle	A	Yes
233	80	32.1	3.1	11.3	5.3	5,935	OnTest	A	No
234	80	32.1	3.1	11.3	5.3	5,935	OnTest	A	No
235	80	32.1	3.1	11.3	5.3	5,935	OnTest	A	No
236	80	32.1	3.1	11.1	5.2	4,465	OnTest	A	No
237	80	32.1	3.1	11.1	5.2	4,465	OnTest	A	No
238	80	32.1	3.1	11.1	5.2	4,465	OnTest	A	No
239	80	32.1	3.1	10.9	5.1	4,465	OnTest	A	No
240	80	32.1	3.1	10.9	5.1	4,465	OnTest	A	No
241	80	32.1	3.1	10.9	5.1	4,465	OnTest	A	No

#### 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

- $\sigma$  = 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

#### 5.4.1 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 <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>
Value	-128.752	57,380.063	56.536	-34,128.551
Standard deviation	21.218	8,358.466	15.020	6,286.583

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

#### 5.4.2 Results of SEM (Standard-Extrapolation-Method), extrapolated time limits

Calculated with the maximum test time ( $t_{\max}$ ) at 80 °C there are following extrapolation time limits:

T <sub>t</sub> = 80 °C, t <sub>max</sub> = 6,949 h				
Temperature T [°C]	ΔT [°C]	k <sub>e</sub>	t <sub>e</sub> [h]	t <sub>e</sub> [a]
20	60	100	762,595	87.05
60	20	6	45,756	5.22
80	0	1	7,626	0.87

### 5.4.3 Results of SEM (Standard-Extrapolation-Method), extrapolated values of strength

Following values of strength are represented:

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

$\sigma_{LPL}$  = 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  $\sigma_{LPL} = \sigma_{(T, t, 0,975)}$ )

$\sigma_{LTHS}$ -values [MPa]								
Time [h]	1	10	100	1000	8760	10000	100000	438000
Temperature [°C]								
20	13.139	12.644	12.167	11.708	11.291	11.266	10.841	10.577
60	8.856	8.422	8.010	7.619	7.267	7.246	6.891	6.673
80	6.935	6.548	6.182	5.837	5.530	5.512	5.204	5.016

$\sigma_{LPL}$ -values [MPa], confidence limit, one-sided = 0,975								
Time [h]	1	10	100	1000	8760	10000	100000	438000
Temperature [°C]								
20	12.554	12.119	11.681	11.238	10.815	10.789	10.336	<b>10.045</b>
60	8.378	7.986	7.597	7.213	6.854	6.833	6.460	6.227
80	6.500	6.156	5.820	5.491	5.188	5.170	4.858	4.663

#### 5.4.4 Results of SEM, 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); German version EN ISO 12162:2009",  $\sigma_{LPL} = 10.045$  MPa at 20 °C for **Black PE 100/ADVANCENE bEEB5906AAH** after a time of 50 years is equivalent to the **preliminary MRS (Minimum required strength) value 10 MPa**.

## 6 Graphical presentation of the results

### 6.1 Graph from Pipeson Analyzer Version 3.2.6

