February 2004

Classification Code: Confidential

Final Technical Statement on YUZEX 6100 BL

A black high density PE100 polyethylene pipe grade resin manufactured by SK Corporation, Daejon in Korea.

SK Corporation.
Daejon.
Korea.
Project number: CDS/121416-4/SE/SMN/V.

GASTEC CERTIFICATION

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Principal : SK Corporation.
Project members : A. Setz,
E. Slootman,
J. Braamhaar

CDS/121416-4/SE/SMN/V

FEBRUARY 2004

SUMMARY OF TESTS PERFORMED AT GASTEC CERTIFICATION LABORATORIES.

In this final technical statement a summary has been made about the suitability for use in pressure pipe systems (such as for gas or water) of YUZEX 6100 BL, a black PE 100 pipe grade resin for pipes and fittings.
This PE-pipe grade resin has been manufactured and produced by SK Corporation in Korea, utilising the Mitsui-Slurry two-stage (bi-modal) process for ethylene polymerisation and using C4 as the co-monomer. The Full-Long-term hydrostatic strength evaluation on this pipe grade resin, performed at GASTEC Certification laboratories on 92 pipe samples in total has been finished in January 2004.
As the multiple-linear regression analysis show, the (ductile) long-term strength value at 50-Years is > 10.0 MPa.

With respect to ISO-4437: 1997 (E) included ISO-9080: 2003 (E), the 50-Years (ductile) long-term strength value (σLPL) at 20°C–(97.5% - LCL) is **10.345 MPa**. See also Appendix 1 to this statement.

The calculated 50-Years value at 20°C has been determined by means of multiple-linear regression analysis, based on data originating from internal water pressure testing at various temperatures on Ø 32 mm - SDR 11 pipe samples in a 20°C, 60°C and 80°C water environment.

The multiple linear regression analysis has been carried out in accordance with the 4-Parameters Model. The obtained 50-Years ductile (σ LPL) value of 10.345 MPa clearly meets the present requirement for a PE 100 (MRS 10) pipe material as laid down in relevant ISO-documents.
A good lack of fit in the ductile modes of the regression-curves based on the performed analysis, has been obtained with significant probability levels. The final technical statement about this pipe grade resin is also supported by results obtained from important mechanical testing carried out at GASTEC Certification B.V. laboratories, such as:

- Determination of the resistance to Rapid Crack Propagation (RCP-testing/$P_{c\text{-}S4}$) carried out in conformity with ISO-13477: 1997 (E) at 0°C on the examined Ø 110 mm - SDR 11 pipe samples, giving a Critical Pressure (Pc,S4 value) of **7.50 bar**.

- Determination of the resistance to Slow Crack Growth (Notch Pipe Testing) in a 80°C water environment, carried out in conformity with ISO-13479: 1997 (E) and ISO-1167: 1996 (E) on Ø 110 mm SDR 11 pipe samples, giving 3 times stress time failure points of **> 10.000 hours**, clearly exceeding the minimum requirement of ≥ 165 hours.

  All tests carried out show satisfactory results.

Hence, regarding the before written observations and conclusions, the YUZEX 6100 BL PE-pipe grade resin is classified as a PE 100.

Signed by:

Guus Setz,
Senior Product Manager,
GASTEC Certification B.V.
The Netherlands.

CDS/121416-4/SE/SMN/V

February 2004

Appendix 1:

Output of the most actual Multiple Linear Regression Analysis performed in accordance with ISO/9080 of 2003, based on the 4-Parameters Model.

Appendix 2:

Accreditation Certificate of GASTEC Certification B.V.

See next pages.

Internal water pressure testing

CASTEC Certification B.V.
Postbus 137, 7300AC APELDOORN
Wilmersdal 5[illegible]7327 AC APELDOORN
Tel. 055-5393[illegible] Fax 055-5393635

Temperature (°C)	Stress (MPa)	Time (hour)	Type of failure
20	12.60	111.12	A
20	12.60	132.50	A
20	12.60	134.59	A
20	12.50	150.15	A
20	12.50	189.52	A
20	12.50	225.04	A
20	12.40	173.14	A
20	12.40	182.59	A
20	12.40	194.19	A
20	12.40	241.66	A
20	12.30	233.07	A
20	12.30	247.88	A
20	12.30	267.86	A
20	12.30	337.01	A
20	12.00	416.20	A
20	12.00	478.51	A
20	12.00	535.92	A
20	12.00	684.35	A
20	12.00	702.18	A
20	11.70	1844.49	A
20	11.70	1891.18	A
20	11.70	2395.72	A
20	11.55	3151.36	A
20	11.55	3888.78	A
20	11.45	4110.82	A
20	11.45	7477.90	A
60	7.80	15.14	A
60	7.80	25.82	A
60	7.80	30.94	A
60	7.75	18.41	A
60	7.75	30.57	A
60	7.75	32.23	A
60	7.70	40.18	A
60	7.70	51.60	A
60	7.70	59.69	A
60	7.70	38.77	A
60	7.70	1136.26	A
60	7.60	96.90	A
60	7.60	116.65	A
60	7.60	167.11	A
60	7.60	189.17	A
60	7.50	225.18	A
60	7.50	270.23	A
60	7.50	448.94	A
60	7.50	507.05	A
60	7.50	1314.96	A
60	7.40	650.67	A
60	7.40	1006.28	A
60	7.40	1980.60	A
60	7.35	1254.15	A
60	7.35	1384.36	A
60	7.30	7868.04	A
60	7.30	7924.06	A
60	7.25	7839.26	A
80	5.85	12.32	A
80	5.85	18.45	A
80	5.85	20.77	A
80	5.80	25.43	A
80	5.80	32.22	A
80	5.80	43.11	A
80	5.70	57.52	A
80	5.70	76.02	A
80	5.70	81.01	A
80	5.70	133.25	A
80	5.60	429.23	A
80	5.60	465.34	A
80	5.60	525.05	A
80	5.60	1015.90	A
80	5.50	515.74	A
80	5.50	550.94	A
80	5.50	704.04	A
80	5.50	732.38	A
80	5.50	813.60	A
80	5.40	2572.14	A
80	5.40	3178.33	A
80	5.40	9769.48	A
80	5.35	4431.62	A
80	5.35	7025.61	A
80	5.30	6979.57	A
20	11.30	9520.10	A
20	11.30	9789.48	A
20	11.15	12782.00	A
20	11.15	12780.00	A
60	7.25	9843.79	A
60	7.20	12830.00	A
60	7.20	12830.00	A
80	5.30	9769.56	A
80	5.20	10508.80	A
80	5.20	10510.10	A
80	5.00	15009.00	A
80	5.00	15009.00	A

Temperature (°C)	Stress (MPa)	Time (hour)	Type of failure
80	5.00	15009.00	A

Model : LOG(time) = C(1) + C(2)/T + C(3) * LOG(STRESS) + C(4) * LOG(STRESS)/T

TYPE A FAILURE

```
Residual variance            =   0.170141
Number of points             =  92
Number of parameters         =   4
Number of degrees of freedom =  88

Parameter estimates

          Value     Std. Error     t value      Pr(>|t|)
C(1)    -128.030        10.420     -12.287         0.000
C(2)   56489.524      4053.450      13.936         0.000
C(3)      48.647         7.594       6.406         0.000
C(4)  -31043.455      2999.114     -10.351         0.000

Test of fit :  Pr[F(26;62) > 10.454] = 0.000
```

TYPE A FAILURE

Prediction (hour)

Time (hour) / Temperature (°C)	1.00	10.00	100.00	1000.00	10000.00	100000.00
20	13.477	12.946	12.436	11.945	11.475	11.022
60	8.562	8.131	7.721	7.332	6.963	6.612
80	6.506	6.136	5.786	5.457	5.146	4.853

Lower Prediction Limit (hour), Confidence Level (one sided) = 0.975

Time (hour) / Temperature (°C)	1.00	10.00	100.00	1000.00	10000.00	100000.00
20	13.015	12.514	12.026	11.549	11.083	10.629
60	8.193	7.787	7.396	7.019	6.657	6.309
80	6.188	5.842	5.510	5.194	4.891	4.602

Prediction (year)

Time (year) / Temperature (°C)	0.50	1.00	10.00	50.00	100.00
20	11.641	11.501	11.048	10.741	10.612
60	7.093	6.983	6.631	6.396	6.297
80	5.255	5.163	4.869	4.673	4.592

Lower Prediction Limit (year), Confidence Level (one sided) = 0.975

Time (year) / Temperature (°C)	0.50	1.00	10.00	50.00	100.00
20	11.249	11.110	10.655	10.345	10.213
60	6.785	6.677	6.328	6.093	5.994
80	4.998	4.908	4.619	4.425	4.343

Extrapolation limits for Polyolefins polymers

Extrapolation limits : Tmax = 60 (°C), tmax = 10020.42 (hour)

TPred	DeltaT	Ke	tlim(hour)	tlim(year)
20	40	50	501021.08	57.19

Extrapolation limits : Tmax = 80 (°C), tmax = 13014.97 (hour)

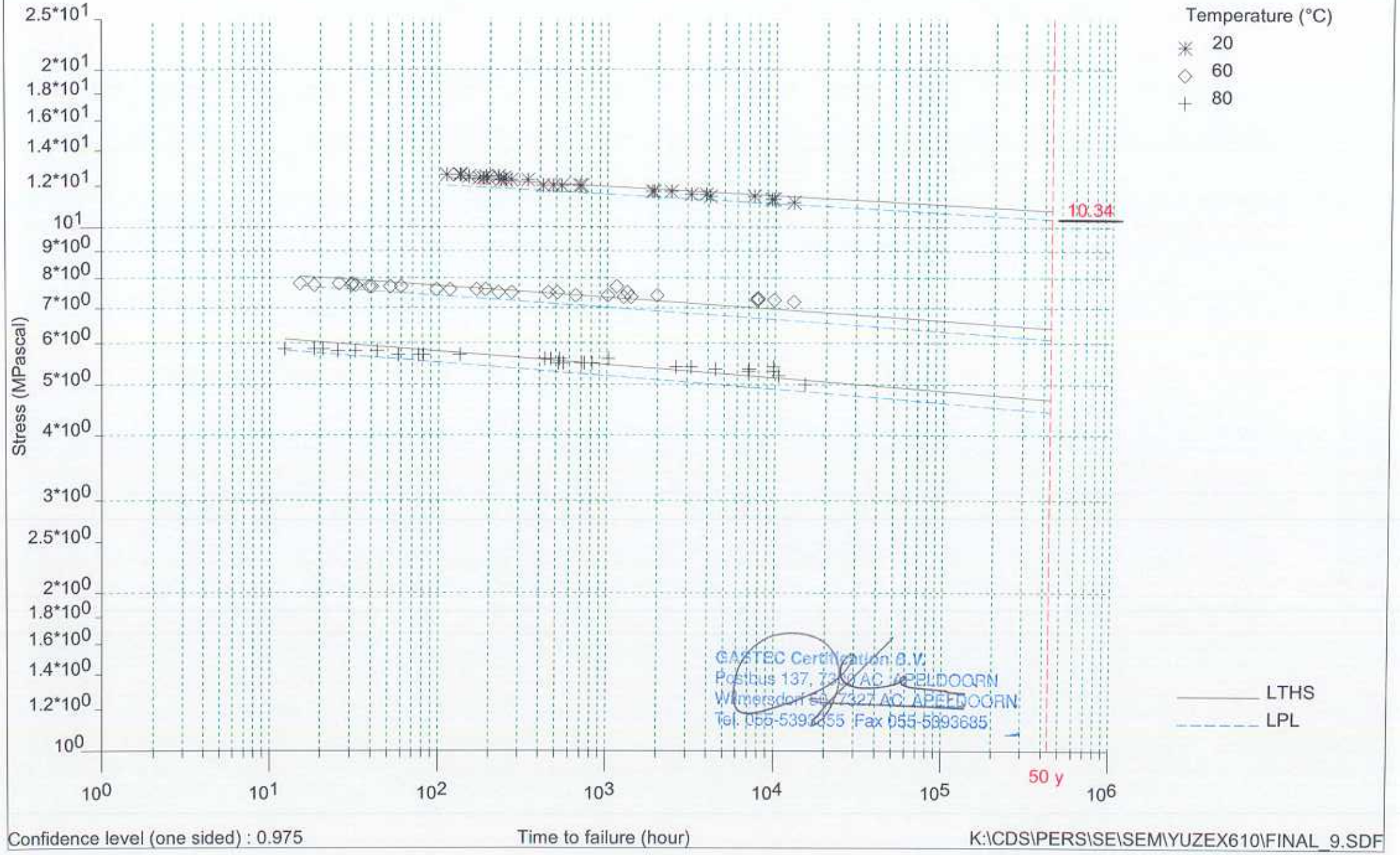
TPred	DeltaT	Ke	tlim(hour)	tlim(year)
20	60	100	876000.00	100.00
60	20	6	78089.80	8.91

NO KNEE PRESENT

SEM 1.15 - 4 Parameters Model

16-04-04 11:45:01

SK Corporation YUZEX 6100 BL



Confidence level (one sided) : 0.975

K:\CDS\PERS\SE\SEM\YUZEX610\FINAL_9.SDF

DUTCH ACCREDITATION COUNCIL RvA

PO Box 2768 NL-3500 GT Utrecht

The Dutch Accreditation Council RvA, operating as accreditor for test laboratories, hereby declares that

Gastec Certification B.V.
Laboratorium Controls, EMC, Distributie- en Installatiematerialen
Apeldoorn

complies with the accreditation criteria for test laboratories as laid down in ISO/IEC 17025:1999. The accreditation covers the quality system of the laboratory as well as the specific activities as described in the authorized annex bearing the accreditation number. As a consequence the quality system of the test laboratory meets the quality system requirements of ISO 9002:1994.

The accreditation is valid provided that the laboratory continues to meet the criteria as laid down by the Dutch Accreditation Council RvA.

This certificate with accreditation number:

L 326

is granted on 19 February 2003 and is valid until

30 September 2006

The accreditation has been granted for the first time on

30 September 1998

The Chief Executive

Ir. J.C. van der Poel

ACCREDITATION CERTIFICATE